MASSACHUSETTS
AGRICULTURAL EXPERIMENT STATION

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Annual Report

For the Fiscal Year Ending November 30, 1941

The main purpose of this report is to provide an opportunity for presenting in published form, recent results from experimentation in fields or on projects where progress has not been such as to justify the general and definite conclusions necessary to meet the requirements of bulletin or journal.

MASSACHUSETTS STATE COLLEGE
AMHERST, MASS.

MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION

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CONTENTS

ANNUAL REPORT OF THE MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION -- 1941

DEPARTMENT OF AGRICULTURAL ECONOMICS AND FARM MANAGEMENT

A. H. Lindsey in Charge

Competitive Factors Influencing the Supply of Market Milk and Cream in Massachusetts. (A. A. Brown and Mabelle Booth.) The manuscript on the Production and Price of Milk in the Springfield–Holyoke–Chicopee Milkshed has reached the final stages of editing. This report is the third in a series pertaining to the shed and represents a tentative appraisal of the forces affecting the origin of the milk supply. The principal one appears to be the system of pricing f. o. b. the market. In secondary markets this type of pricing underlies the inefficiencies in transportation which in turn are probably a cause of the non-economic pattern of milksheds. A reasonable correction would seem to be a shift to pricing f. o. b. the farm.

An Analysis of Selected Merchandising Practices in the Fruit and Vegetable Industry. (A. A. Brown and Mabelle Booth.) A record of the operations on the Boston Regional Produce Market in 1941 has been secured in addition to that of 1940. Cursory examination indicates that conditions were similar in both seasons. Most of the farmers using the market are small operators. The majority of them used it only a few times during the season. A few of them, however, are large operators who supplied the bulk of the produce.

The financial situation of the market corporation is its chief obstacle to growth. Because of this, the fixed plant remains undeveloped. Until a greater degree of permanency is assured, improvements such as store and storage facilities are not probable. Lack of these facilities keeps wholesalers and jobbers away from the market; shipped-in produce is not generally available; buyers go to other markets where complete supplies may be had.

Crop and Livestock Enterprise Relationships to the Farm Business in Massachusetts. (C. R. Creek.)

Vegetable Growing in Bristol County, Massachusetts, in 1940. Records of the farm business were obtained on 22 specialized vegetable farms and on 10 livestock–vegetable farms for 1940. Since the season was more nearly normal than in 1939 in regard to yields and prices for vegetable crops, the 22 specialized farms showed a net cash return over cash operating expenses ranging from a gain of $8,022 to a loss of $270 per farm.

Average returns for the livestock–vegetable farms were lower than for the specialized vegetable farms in 1940. The livestock enterprises showed a return over costs but the important crops—potatoes, sweet corn, and cabbage—were relatively unprofitable in 1940. On many farms income from the livestock enterprises prevented a loss in net returns.

Recommendations for improved practices and management were made on the basis of results obtained from this study. Many small farms have incurred unnecessary losses in recent years chiefly because of poor management and lack of adjustment to changing conditions in vegetable growing and marketing.

Results of this study were published in Mimeograph FM8 in October 1941, under the title, "Vegetable Growing in Bristol County, Massachusetts, in 1940."

Two Years of Vegetable Growing in Bristol County, Massachusetts—1939 *and* 1940. The farm records for 1939 and 1940 on the specialized vegetable farms were studied to determine the reasons for the increased returns in the latter year. Net cash return averaged $1777 per farm in 1940 compared to a loss of $4 in 1939. Records were obtained for 20 of these 22 farms in both years.

Higher yields and higher prices for four important crops were chiefly responsible for the higher returns. The acres of crops per farm were practically equal, cash farm expenses increased only 20 percent over 1939, but sales of produce increased 60 percent. Yields and prices increased greatly in 1940 over 1939 for iceberg lettuce, cucumbers, green beans, and early tomatoes. Yields were maintained for sweet corn, late tomatoes, cabbage, and potatoes, but prices were lower particularly for cabbage and tomatoes.

Net cash returns for the livestock–vegetable farms were slightly lower in 1940, with an average of $1399 compared to $1453 in 1939. Number of cows and acres of crops for sale were the same in both years, but the average size of poultry flocks increased slightly. Unprofitable crops such as potatoes, cabbage, and sweet corn were responsible for the lower returns in 1940.

Budget analyses were made for a small and a large specialized vegetable farm and for a livestock–vegetable farm to show expenses, income, yields, and prices for the two years. Diversification of the farm business on the latter farm was discussed in relation to the more uniform returns in both years. Preliminary recommendations for improving the farm business were made on the basis of this two-year study.

Results of this study were published in Mimeograph FM9 in October 1941 entitled, "Two Years of Vegetable Growing in Bristol County, Massachusetts—1939 and 1940."

Diversification of the Farm Business. In response to a request from the Subcommittee on Diversification, of the Essex County Rural Policy (Land Use Planning) Committee, a summary was made of farm records from previous studies to show the effect of various types of diversified farm businesses on farm organization and net returns.

Diversity by the processing and distribution of farm products was shown to be very profitable in the case of retail dairy farms from the 1936–37 study of dairy farm management. With the same number of cows per herd, but receiving 7 cents per quart extra for milk, the retail farms had net cash returns four times greater than the specialized wholesale dairy farms. In the case of poultry farms for 1937 this method of diversification was not so profitable. The retail farms had larger flocks, and more eggs were sold at a price 6.5 cents per dozen higher; but net cash returns and farm income were almost equal to those on the specialized wholesale poultry farms. Cash operating expenses were too high and the spread from wholesale to retail price was too narrow for extra profitable operation of these retail farms.

Wholesale dairy farms with a fruit or vegetable enterprise were generally more profitable than the specialized dairy farms. Because of unfavorable price relationships in 1936, the combination of dairy and poultry enterprises was less profitable.

Another method of diversification on poultry farms was the selling of hatching eggs or baby chicks in addition to market eggs, broilers, and fowl. The more intensive of these hatchery farms with 30 percent of cash receipts from the sale of baby chicks and pullets showed the highest net returns of any group in the 1937 study. The wholesale egg farms with some hatching egg and baby chick business were the next most profitable, although the price received for market eggs was lowest. Largest size of laying flock, highest egg production per hen,

and a balanced farm business in the growing of flock replacements were contributing factors to high farm returns.

A balanced or diversified farm business will tend to produce a net return year after year in contrast to high returns and losses on specialized farms. In general a diversified farm business is to be desired, although not all farms of this type are profitable.

Labor Saving Methods and Practices on Massachusetts Farms. (C. R. Creek.)

Harvesting and Packing Iceberg Lettuce. The results of this study on vegetable farms were published in Mimeograph FM5, February 1941. Diagrams of packing shed equipment and layout were included as well as descriptions and discussions of various methods of harvesting and packing.

Harvesting and Packing Tomatoes. This study was published as Mimeograph FM6 in March 1941 and contained descriptions of methods and practices in harvesting and packing tomatoes in different types of containers for various markets. Diagrams of packing equipment such as conveyor belts, tables, and trays are included, plus time data on the efficiency of different methods.

Harvesting and Packing Celery. This study was published as Mimeograph FM7 in May 1941 and supplements a previous description and analysis of packing operations on farms producing celery. Information on equipment and practices in the field work of harvesting celery and a diagram of the packing shed layout for the handling of celery and carrots was included.

Rural Credit in Massachusetts. (A. H. Lindsey and Sargent Russell.) During the year, 273 survey records of 1940 farm operations were taken covering 10 towns in 5 counties of the State. Analysis has not been completed but preliminary conclusions are as follows: (1) The best incomes can be obtained by farmers when they combine non-farm work, such as retailing of their produce, selling grain or machinery, or working off the farm, with their farm operations; (2) In 1940 poultry paid better than dairy, and dairy better than vegetable; (3) Farmers on the whole know where to borrow money at reasonable rates; (4) Farmers borrow as little as possible and although many could use more capital they have restricted their borrowing, not because the money isn't available, nor because their credit standing isn't satisfactory, but because difficulties of repayment outweigh the advantage of increased income due to the investment; (5) In spite of what appears to many as a chronic low income for farm operators, farmers do continue to accumulate an estate in Massachusetts; (6) Tenancy (100 percent rented farms) is low, part ownership and part rent occurs on more than a third of the farms; (7) About two-thirds of the farms have mortgages, and on about one out of every three mortgaged farms the mortgage amounts to over half of what the farmer estimates his farm is worth; (8) The ability of the operator is probably the most important variable in farm operation. The better operators achieve greater success primarily because they have: (a) Good size of business, (b) efficient use of labor, (c) above average crop and livestock production, and (d) good balanced use of all resources (diversity).

Land Tenure in Massachusetts. (A. H. Lindsey and Edward Collins.) The United States Census does not give a complete picture of land tenure in Massachusetts. The 6 percent of tenancy reported by the Census refers to leased whole farms. Our survey shows that another 31 percent of farm owners rent land in addition to their own. This may be properly termed "field renting."

Six percent of the farms available for lease is not sufficient to provide opportunity for prospective owners to use farm tenancy as a "rung" in the agricultural ladder in achieving ownership. The most popular way of earning an equity for the purchase price of a farm was to work as an industrial laborer.

The practice of field renting enables Massachusetts farmers to enlarge their farm business and thus to increase their family income. A loss of these areas would reduce individual farm business to an uneconomic size. Rented fields which are under cultivation usually are satisfactorily maintained but practices are not equal to those on owned land. Conservation practices on rented hay and pasture land were much poorer than on owned land. Eighty-five percent of rented fields were used for hay or pasture. Nine out of ten of the field-renting leases were oral as compared to two out of three where whole farms were rented. Of the part owners who were renting fields, 97 percent received no supervision or direction from the land owners regarding the use of the land.

DEPARTMENT OF AGRONOMY

Walter S. Eisenmenger in Charge

Tobacco Projects. (Walter S. Eisenmenger and Karol J. Kucinski.)

Brown Root-Rot of Tobacco. Experience has shown that the presence of high amounts of lignin in the crop preceding tobacco is generally associated with the presence of brown root-rot of tobacco. It is well known that the lignin content of plants increases from the seedling stage to maturity. With this in mind, twelve crops—tobacco, artichoke, corn, oats, buckwheat, barley, rape, millet, rye, wheat, sudan grass, and sorghum—were all sown at the same time, and one third of the area of each was plowed under at three different stages of maturity of the plants. Tobacco was planted on all areas the following year.

When those plants having a relatively high lignin content, such as sudan grass, sorghum, corn, millet, rye, barley, and oats, were plowed under at maturity, the tobacco grown on these plots the following year had lower yields and lower crop indexes than tobacco grown following the same plants plowed under before they reached maturity. With those plants low in lignin, such as tobacco, artichoke, and rape, the stage of maturity of the plant did not produce the same effects as in the case of the high-lignin plants.

The Effect of Additions of Plant Tissue to Tobacco Land. A corn crop preceding tobacco is injurious to the following tobacco crop. In order to find out whether this injurious effect is due to the presence of abnormal amounts of fibrous tissue or to the removal of nutrients consequent on the growth of the corn, corn stover, in pieces about one inch long and in amounts comparable to that usually grown on a given area, was applied to soil which was to be planted to tobacco. A decrease in both yield and quality of the tobacco crop resulted.

These results are no doubt traceable to the high lignin content of the corn stover applied, because it is generally known that organic matter of this sort has a tendency to lower the available nitrogen in the soil to which it is applied.

Tobacco Experiments with Application to Soil of Commercial Organic Materials. It has been suggested that the source of organic compounds might possibly determine the yield and quality of the subsequent tobacco crop. Sugar, carbon (charcoal), dry skim milk, and starch were the materials selected for comparison. They were applied at the rate of two tons to the acre. A fifth plot, to which nothing was added, was included as a check.

There was little difference in the action of these different materials. The applications of charcoal or carbon gave the highest yield, as was anticipated from the appearance of the crop in the field; but the quality of this tobacco lowered the crop index value.

The Absorption by Food Plants of Chemical Elements Important in Human Nutrition. (Walter S. Eisenmenger and Karol J. Kucinski.) Some plants have the ability to take up certain chemical elements from the soil in amounts greater than normal, depending both on the ion involved and on the species of plant.

In previous trials, an increase in the amount of magnesium, sodium, potassium, and chlorine added to the soil resulted in increased intake by the plant. In the present experiments, sodium, potassium, and magnesium were compared with calcium; and phosphate and sulfate were compared with chlorine, bromine, and iodine, in this respect.

The increased intake of potassium, sodium, or magnesium, due to the addition of these ions to the soil, was more pronounced than the increase in calcium resulting from the addition of similar chemical quantities of calcium. Also, the percentage increase of chlorine, bromine, and iodine in the plants when these elements were added to the soil was higher than that of sulfur or phosphorus when similar chemical quantities of these anions were added.

This indicates that those elements which are more abundant in sea water than in soil water are the ones which can be introduced into plant tissue with little difficulty. In some respects it would seem that our land plants have not fully adjusted themselves to a land environment.

The Intake by Plants of Elements Applied to the Soil in Pairs Compared to the Intake of the Same Elements Applied Singly. (Walter S. Eisenmenger and Karol J. Kucinski.) Cabbage, lettuce, beans, and celery were grown on plots to which various elements had been added, in pairs, in quantities known to be excessive but not toxic. Chemicals compounds, used in all possible combinations of two, supplied calcium, potassium, and sodium at the rate of 250 parts per million of soil and lithium at the rate of 100 parts per million. The exceeding toxicity of lithium to plants necessitated application at the lower rate and at a considerable time before planting. The calcium intake by cabbage, celery, and lettuce was decreased when either sodium or potassium salts were applied with the calcium. The potassium intake was increased in this combination. The lithium intake was decreased when potassium was applied with the lithium. The potassium intake was decreased somewhat when plants were grown on a combination of potassium and sodium.

Magnesium Requirements of Plants. (Walter S. Eisenmenger and Karol J. Kucinski.) Various species of plants have been grown on a plot known to be deficient in magnesium. There is little evidence to indicate a reason for the varied reactions of different plants to the scarcity of magnesium ions in the soil. Different members of the same family react differently. Sudan grass shows no symptoms, nor does timothy; but regular field corn becomes chlorotic, and hybrid sweet corn scarcely sets any seed. Pumpkin vines show distinct chlorosis; watermelons do so only at maturity.

There is evidence now that plants may suffer from the lack of this element, yet may not show any chlorosis or lack of chlorophyll formation. Strawberry plants do not become chlorotic, yet new runners are formed more abundantly and the strawberry row is wider where magnesium is applied, while the row becomes narrow where no magnesium is applied. The very common garden weed, purslane (*Portulaca oleracea*), called by the farmer "pussley," forms a thick mat where magnesium was applied and ceases to grow, except in rare instances, where the soil is deficient in magnesium. If a plant can be found, it is not chlorotic. Apple leaves from trees on magnesium-deficient soils are not chlorotic, but areas of the leaves become dark brown and eventually die, much like the leaves from a potash-deficient plant.

On areas of the plot where lime was applied, the sugar content of the fruits was increased in some instances. This was true of blueberries and grapes, but not of watermelons.

The Absorption and Excretion of Potassium and Calcium by the Roots of Barley in Different Solution Media and Changes in pH. (Walter S. Eisenmenger and George Wenzel.) Determinations were made of the absorption and excretion of potassium and calcium, by (barley) plants and excised root systems of barley, from and into one-salt solutions of different concentrations, and into distilled water. A study of the changes in hydrogen-ion concentration of the solutions was also included. The salts used were acid potassium phosphate (KH_2PO_4), and calcium nitrate ($Ca(NO_3)_2$). The length of the experimental period was 72 hours in all tests.

The intensity of absorption and excretion increased with the length of the experimental period. In general the absorption increased rapidly after the first 24 hours, while the excretion increased slowly throughout.

The reaction of the media was never stable in the presence of live root systems. The pH values increased during the daylight hours and decreased somewhat during the night. The continual change of pH values was, undoubtedly, tied up with absorption and excretion phenomena of electrolytes, but to state that the degree of change was absolutely proportional to the rates of absorption and excretion would imply the exclusion of buffer action and other controlling factors.

The proportion of absorbable ions absorbed during a given period decreased as the concentration of these ions in the solution decreased. In this way plants can adapt themselves, to a considerable extent, to solutions of low concentration.

For the first two days potassium was more firmly held by the roots than calcium, after which calcium was excreted in larger amounts, but no considerable excretion of either was observed. The excretion of ions into salt solutions was greater than into distilled water.

An equivalent absorption and excretion of calcium and potassium did not take place, except for extremely short periods.

The results with excised roots show that roots alone are not capable of a uniform absorption of ions.

Attention is called to the fact that energy exchanges are involved in the processes of absorption and excretion. Permeability and osmosis alone are inadequate to explain these phenomena in the living plant.

Sunflowers and Their Possibilities. (Karol J. Kucinski and Walter S. Eisenmenger.) This year's growing season was an exceptionally good one for sunflowers, which grew to maturity and formed very large seed heads. Seedings of one seed per hill every 18 inches in 36-inch rows produced a yield of over two tons per acre of well-formed large seeds. This yield is much larger than that obtained in past years, indicating that a good corn-growing season is also a good sunflower season. At the current wholesale market price of sunflower seed the value per acre is about $225 to $250. This crop would seem to have great possibilities if grown commercially, even on some of our lands which have a high per acre valuation. Since it is somewhat difficult during this present national emergency to import from abroad as much sunflower seed as is necessary, it might be feasible for some of our farmers to grow the crop commercially.

The oil obtained from sunflower seed is very high in content of vitamins A and D, but it is used in this country primarily as a drying oil in paints. In eastern continental Europe the peasant population has always eaten the seed. It has been thought by some scientists that this seemingly habit-forming practice of eating the sunflower seed is an instinctive effort on the part of the individual to supplement his usual deficient diet with the high nutritive contents of the

Soil Conservation Research Projects. (Karol J. Kucinski and Walter S. Eisenmenger.)

A Study of the Physical and Chemical Properties of Wind-Blown Soils. Only certain types of soil in Massachusetts are normally affected by wind. The object of this study is to determine whether there is any relation between the physical-chemical properties of these soils and their susceptibility to wind erosion. Soils from wind-eroded and non-wind-eroded areas have been examined for their physical and chemical properties, such as mineral and organic colloidal fractions, plasticity, hygroscopicity, mechanical analysis, heat of wetting, heat of conductivity, capacity of absorption, and such other soil properties as are deemed of value. The effect of chemical and physical charges in soil, brought about by the addition of fertilizer, lime, or organic matter, has been studied by means of a small wind tunnel. Preliminary tests were sufficiently satisfactory to warrant the construction of a larger wind tunnel with certain modifications which should make it more suitable for the purpose.

Experimentation with Topsoil Removal. (In collaboration with Arthur B. Beaumont.) In order to measure the effects of loss of topsoil on yield, the topsoil (to plow depth) was totally removed from one plot with a bulldozer, while an adjacent plot was left undisturbed as a check. Spring wheat and white sweet clover were grown on fertilized and unfertilized portions of these two areas.

The increases in yield due to fertilization were significant on both areas. However, the decreases in yield due to topsoil removal are alarming. With spring wheat, the decrease in yield where the topsoil had been removed was 63 percent on the fertilized plot and 91 percent on the unfertilized. With white sweet clover, the results were even more extreme: where topsoil had been removed, there was 81 percent decrease in yield on the fertilized plot and total crop failure (100 percent decrease) on the unfertilized plot. These results show the value of the topsoil and the loss to the farmer if his topsoil were totally removed at one time. Under normal conditions only a small part of the topsoil is removed each year by erosion, and the farmer is not so conscious of his loss.

Nature of Soil Erosion in Massachusetts. (Arthur B. Beaumont and Karel J. Kucinski.) Accelerated water erosion of Massachusetts soils is widespread but of slight to moderate intensity. However, cultivation of steep slopes through a long period has caused the removal of the entire original topsoil in places and its accumulation at the foot of slopes within comparatively short distances from the point of origin. The character of the soils is important as affecting the nature of the erosion. Being of medium texture and low in colloidal matter, they have low suspensibility in water. A preliminary examination of important soil types gave dispersion ratios ranging from 9.3 to 15.3 with most of them below 11.0. Because of the low suspensibility of the soils, they are deposited as soon as the velocity of the water carrying them is slightly lessened. Streams in this section rarely run muddy, and then only at times of high flood.

The pictures on page 53 illustrate (1) the difference in the suspensibility in water of Merrimac fine sandy loam, an important soil of the Connecticut Valley, and Memphis silt loam, an important soil of the Mississippi Valley; and (2) the depth of topsoil accumulated by sheet erosion of a cultivated Massachusetts slope.

Experimentation with Historical "Soil-Test Plots." (Walter S. Eisenmenger and Karol J. Kucinski.) Fifty-one years ago a series of plots was inaugurated to study the effects on the soil and crops of a long-time fixed-fertilizer program. The purpose was to find out the fertilizer needs of the soil tested. Results of these tests published about twenty years ago showed "that fertilizer needs are

determined as much by the farming system followed and the kind of crops grown as they are by the type of soil being farmed."

Since that time these plots have been used for experiments with fruit trees, following the original system of fertilization. The fruit trees have now been removed, leaving a field with limed and unlimed portions of plots which for the past fifty years have had applications of nitrogen, potash, and phosphoric acid, singly and in various combinations. The check plots have been left unfertilized during the entire period. Preliminary observations during the past year have shown that the fertility level of all the plots is much higher on the limed than on the unlimed portions. The unlimed portions of the check plots showed crop failures and indications of nutrient deficiences.

It is the intention to continue this study with the view of observing more carefully the various nutrient deficiencies singly and in combination as they appear in the various crops to be grown on this area.

Potato Variety Trials. (Ralph W. Donaldson, Walter S. Eisenmenger, and Karol J. Kucinski.) Based on yields of marketable size, the ranking of potato varieties grown in plots at the college during the season of 1941 were Sequoia, Earlaine No. 2, Green Mountain, Russet Rural, Katahdin, Houma, Irish Cobbler, Red Warba, Sebago, and Chippewa.

Soil Nitrates Lower pH Reactions. (Ralph W. Donaldson, Walter S. Eisenmenger, and Hrant M. Yegian.) A marked depression of pH reactions which occurred in potted soil as nitrates formed and accumulated was mentioned last year in reporting "the effect of fineness of limestone on soil reaction."

Results of a similar trial in progress now, covering a 12-month period, substantiate the previous findings. In this later trial oats were successively grown on a duplicate series of limed and unlimed soil, in an attempt to remove by plant assimilation the nitrates which develop. Both the cropped and the uncropped soil of any given treatment first exhibited similar reactions except for slight variations dependent upon ammonia development. When nitrates developed, however, the uncropped soils dropped about .7 of a pH below corresponding cropped soils, depending upon the relative amounts of nitrates present. This situation prevailed within limed and unlimed treatments.

Since the product of organic matter decomposition is ultimately nitrates, which under some conditions may accumulate in the soil solution and cause a lowered pH reading, this factor may be important when recommending lime for sensitive crops like potatoes and tobacco. A field sample which shows high nitrates after harvest may give a pH reading about .5 lower than a sample taken during the active growing period of the crop when nitrates are being absorbed. For example, it is conceivable that a potato soil during the active growing period of the crop may show low nitrates in the soil solution and test pH 5.5; yet when tested after harvest, with nitrate accumulated, it may test pH 5.0, for which a light lime application might (wrongly) be suggested. Whether such differences occur under field conditions at least merits consideration.

Borax Trials on Several Crops. (Ralph W. Donaldson, Walter S. Eisenmenger, and W. G. Colby.) Applications of borax to established stands of alfalfa have been continued on more than 20 farms in the State. Both spring and fall applications at 25 and 50 pound rates have been compared, with no evidence at all of injury from the higher rates. In fields where alfalfa "yellows" appeared this season, borax applied prior to this spring effected marked control. This was evident also in single treatments of 25 pounds per acre applied in the fall of 1939, indicating, thus far at least, a two-season carry-over from treatment. The effect of borax applied in the spring was less marked in controlling yellows on the crop which

followed. A marked deficiency of normal rainfall occurred following application of the borax. Evidence that borax may contribute to longevity of alfalfa is indicated by plant response to two seasons' applications compared with the check in two fields.

Borax was broadcast at 25 pound rates in strips on a variety of crops growing on six market garden farms. The treatments were made early in May, without regard to planting time and seedling stage. In no case did growers observe any injurious effects from the borax.

Fertilizer containing 20 pounds of borax per ton was drilled in bands at a ton rate on an acre of Cobbler potatoes planted by D. Wilson Smith, Scituate. There were no symptoms of plant injury which could be attributed to the borax.

Oat Variety Tests. (W. G. Colby.) Eleven named varieties of oats, including several of the recently developed, smut-resistant strains, were grown at Amherst during the past season. The results are reported in Control Bulletin 111, Seed Inspection (pages 92-93), where these named varieties are compared with a number of lots of commercial seeds.

The Effect of Arsenious, Arsenic, and Antimony Oxides on Soil and Plant Growth. (Walter S. Eisenmenger and Hrant M. Yegian.) Pot culture studies under greenhouse conditions on the effect of arsenious, arsenic, and antimony oxides on Merrimac fine sandy loam and subsequent crop growth are being continued. Six successive crops, barley and buckwheat alternating, were grown in the same soil in pots during 1939 and 1941. On June 11, 1941, tobacco seedlings were transplanted to these treated pots. The tobacco was harvested November 14, 1941.

Arsenious oxide, 500 p.p.m., retarded the growth of tobacco and prevented blossoming; while 500 p.p.m. with organic matter produced a fully mature, normal plant. Concentrations of 1000 p.p.m. or over of arsenious oxide were very toxic even in the presence of organic matter.

Arsenic oxide, 750 p.p.m. reduced the growth of tobacco and prevented blossoming; 750 p.p.m. with organic matter, however, produced a fully mature, normal plant. Concentrations of 1000 p.p.m. or over of arsenic oxide, with or without organic matter, were very toxic to tobacco.

The arsenic content of a few of the tobacco leaves, stems, and seeds was determined[1] by the micro Gutzeit method, modified according to C. C. Cassil. The results of these analyses may be summarized as follows:

1. At the low concentration of arsenic (240 p.p.m. As) in the soil, the stems and leaves contained 3 to 6 p.p.m. As, while none was detected in the seed.
2. At the higher concentration of arsenic (480 p.p.m. As) in the soil, the stem and leaves contained 12 to 18 p.p.m. As, and no seeds were produced.
3. Indications are that the concentration of arsenic in the tobacco leaves exceeds that in the stems. The number of determinations, however, was not great enough to warrant definite conclusions at this time.

The tobacco plants in pots containing 1500 and 2000 p.p.m. arsenious oxide made no growth during the five-month period. At the end of five months these plants were transplanted to As_2O_3 free soil. While these plants have resumed growth, it is not a normal but a rosette growth. This may be due either to the age of the transplants, short daylight conditions, presence of arsenic in the plant, or to a combination of all these factors.

The antimony oxide treatment did not affect the growth of tobacco at any concentration (250 to 2000 p.p.m. antimony oxide).

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[1]By John W. Kuzmeski, Senior Chemist, Control Laboratory of the Massachusetts Agricultural Experiment Station.

Hybrid Field Corn. (Hrant M. Yegian.) There is a definite need for an early-maturing hybrid field corn for the higher plateau regions of Worcester County and the western counties of Massachusetts. Accordingly, 64 strains of hybrid seed corn were planted for trial during the past season. A few of these strains, which matured in 90 to 100 days, will be tested next season in Athol, Massachusetts, against the local-grown varieties in that region. Last season 180 inbred lines and single crosses were crossed with Wis. (CC4×CC8). Most of these crosses will be tested for early maturity and yield this coming season at the College Farm.

Onion Breeding. (Hrant M. Yegian.) Hybrids between *Allium fistulosum* (type Nebuka) and *A. cepa* (type Ebenezer) were secured in the spring of 1940. All the flowers of two umbels from Nebuka plants were emasculated twice daily for about two weeks and dusted daily with pollen grain from Ebenezer. Of the 230 plants from one of the umbels 80 percent were hybrid between the two species. Only 10 percent of the plants were hybrid from the second umbel. Although there were no apparent morphological differences between the hybrids and the Nebuka at the seedling stage, the hybrid plants could be recognized in the field by their vigor, the semi-circular leaves growing close together, and the color of the bulbs. Some of these hybrids will be treated with calchicine in an effort to secure tetraploids.

Sufficient seed for testing has been produced from a strain of Ebenezer selection that will mature bulbs about two weeks earlier than the valley-grown varieties. Final field tests will be made before the strain is recommended to the growers.

Data from a two-year preliminary experiment show that there is no significant difference between the yield of set onions grown in double rows and those grown in single rows 14 inches apart. Planting sets in double rows 4 inches apart and placing the double rows 24 inches apart would greatly facilitate the use of power cultivators.

Influence of Soil Fertility on Productiveness of Pasture Species. (Walter S. Eisenmenger and Hrant M. Yegian.) It has long been observed that there is a close relationship between the fertility of the soil and the botanical composition of the vegetation growing upon it. It would be of great interest, therefore, to know whether there are specific levels of soil fertility which are required by different species of pasture plants in order that they may thrive and maintain themselves over an extended period.

The data covering one year of preliminary field plot experiment on the effect of four levels of soil fertility on thirteen species of grasses in pure stand warrant the following general statements:

1. That all the species responded to increase in soil fertility.
2. That the species which produced poorly at a low fertility level gave much greater percentage increases in yield at higher fertility levels. Meadow foxtail, for example, produced an average of 0.19 pounds of dry hay in the plots that had no fertilizer, and 0.54 pounds (184 percent increase) in the plots treated at the rate of 1600 pounds of 5-8-7 per acre. On the other hand, meadow fescue, which averaged 0.48 pounds of dry hay in no-treatment plots, produced 0.76 pounds (58 percent increase) at the highest fertility level (1600 pounds 5-8-7 per acre). However, in each of the four levels of soil fertility, the species which produced greater total dry weight in no-treatment plots outyielded the species which produced poorly in no-treatment plots.
3. That the better-producing species were those well adapted to the climate. Apparently temperature is one of the important factors influencing yield. Perennial rye grass and fowl bluegrass did well in cool weather, but during the heat of summer they dried out; whereas meadow fescue, reed canary grass, and orchard grass maintained comparatively well-sustained growth throughout the season.

Experiments at Amherst with Pasture Seeding Mixtures. (W. G. Colby.) For the purpose of studying different strains of grasses and legumes under actual grazing conditions, three series of plots were laid out in 1940, on land which had been brought to a high state of fertility through the liberal use of lime, manure, and commercial fertilizer. Two series of 19 plots each were seeded August 23, 1940, and a third series of 13 plots was seeded April 18, 1941. The same mixtures were included in each series as far as possible. In several instances, limited seed supplies prevented the use of certain mixtures in more than one or two of the three series.

The object of the experiment was to compare a system of hay–pasture management with pasturing alone and to test summer seeding of pasture mixtures against spring seeding. During 1941, Series I was subjected to four periods of intensive grazing by a small herd of dairy cows: in May, July, August, and October. Series II was first cut for hay before being subjected to three periods of grazing, which coincided with the last three grazing periods of Series I. The spring-seeded series (III) was grazed only lightly at the same time as Series II. The following observations and results deserve mention:

1. Brome grass and meadow fescue (Svalof's early) showed the most promise as being desirable companion grasses for Ladino Clover. The cutting of an early hay crop followed by several periods of intensive grazing appeared to be the most desirable way of utilizing these grasses.

2. Hay types of orchard grass (Scandia and Commercial) as well as the less vigorous pasture types (S26 and S143) did not combine well with Ladino Clover. The orchard grass, irrespective of how it was managed, tended to crowd out the clover even during the first season. This occurred partly because orchard grass grows vigorously throughout the season and partly because it produces tussocks or bunches. Animals grazing on Ladino Clover mixtures with this grass tended to graze the clover growing between the bunches of orchard grass much more closely than they did the clumps of grass, even though the orchard grass was kept in a young, active vegetative growth stage at all times. As a result of preferential grazing, the stand of orchard grass continually improved and the stand of clover deteriorated.

These observations may explain why, in Massachusetts, orchard grass in Ladino Clover seeding mixtures invariably crowds out Ladino Clover, completely, after three or four years and results in a pure stand of orchard grass.

The most promising mixtures using orchard grass were those which included alfalfa and which were cut for hay before being grazed. For this purpose, the later-maturing pasture strains (S26 and S143) were much superior to the hay strains. There is a real need for a hay strain which will mature from a week to ten days later than do any strains now available.

3. The hay–pasture system of management rather than pasture alone appears to have excellent possibilities as a way of utilizing a number of these early maturing grasses (brome, meadow fescue, orchard) not only in producing a good early hay crop but also in providing excellent feed for midsummer grazing. In these experiments, about two tons of dry hay were cut to the acre in the middle of June, followed roughly by three quarters of a ton of dry herbage as grazing the latter part of July, about the same quantity again late in August, and another half ton early in October.

4. Observations on palatability indicated that timothy ranked first among the grasses, followed in order by brome grass, meadow fescue, red top, orchard grass, and tall fescue (Alta strain). Alfalfa, red clover, and alsike, although quite palatable as young plants, became less palatable than Ladino Clover as the plants became older and developed woody stems. The woody, unpalatable stem growth of alfalfa is a serious handicap to the use of this plant for grazing purposes.

5. A good stand of alfalfa was obtained in all of the hay-pasture mixtures (Series II), but only weak stands were obtained when an early period of grazing took the place of a crop of hay (Series I). Apparently alfalfa must be allowed to become well established before grazing is begun.

6. Bird's-foot trefoil, under the condition of these experiments, showed no promise whatsoever.

COOPERATIVE TOBACCO INVESTIGATIONS

Conducted by the Bureau of Plant Industry, United States Department of Agriculture in Cooperation with the Massachusetts Agricultural Experiment Station

C. V. Kightlinger, U. S. D. A., in Charge

Black Root-Rot. (C. V. Kightlinger.) Black root-rot is one of the most common diseases of tobacco, and probably the most important disease of Havana Seed and shade tobaccos in the Connecticut Valley at the present time. The disease is recognized generally as being highly important on the basis of losses caused by moderate to heavy infections which are easily recognized as black root-rot. Its importance is not so generally recognized when losses are caused by light to moderate infections, largely because of the tendency to accept the low yields as a matter of course instead of attributing them to specific causes, and also because black root-rot is not always easily recognized in cases of light infections, even though they may be sufficient to cause low yields. It is reasonably certain that black root-rot causes light to moderate damage to tobacco in the Connecticut Valley much more generally than is commonly recognized at the present time.

An effective and convenient method of controlling the disease would mean much to the tobacco growing industry. The disease and the conditions under which it occurs are of such a nature, however, as to make resistance to the disease the most feasible control method after soil conditions favorable to the disease have become established; and the use of resistant strains, even before soil conditions favorable to the development of the disease have become established, would permit greater range in fertilizing practices, particularly in the use of lime, than is otherwise advisable, which would often promote the production of better tobacco. Consequently the attempt to develop strains of Havana Seed which are more resistant to black root-rot and more acceptable in type, quality, yield, and certain other characteristics, is being continued. The importance of the disease and the prospects of eventual success seem to justify the continuation of the project.

The plan as it is being worked at the present time is two-fold. In the first place, selections of Havana 211, which is itself moderately to highly resistant to black root-rot under Connecticut Valley conditions but which is not entirely acceptable in type, quality, and certain habits of growth, have been made to improve the strain in type and date of maturity. In the second place, new strains have been produced by crossing strains of Havana Seed which are resistant to black root-rot but not entirely acceptable in type and quality, with strains of common Havana Seed which are not resistant to black root-rot but are acceptable in type and quality, in the hope of obtaining new strains which embody the desirable features of both parents.

Tests of the selections of Havana 211 and of the crosses have been made, and are being made, in the greenhouse and in the field, to determine their value. Some of the selections of Havana 211 show improvements over the original strain in certain characteristics, but little if any improvement in resistance to

black root-rot or in habits of growth. Earlier maturity, which was greatly desired, was not obtained in any of the selections of Havana 211. Some of the selections from the crosses possess sufficient resistance to yield well under black root-rot conditions in the Connecticut Valley, and also show distinct improvements in important characteristics of type and habits of growth, including earlier maturity. Some of these selections are as early maturing as the strains of common Havana Seed which were used in making the crosses. They seem, also, to be superior to either parent in some important characteristics such as shape of leaf and size of veins. These particular strains deserve more testing to determine their full resistance to black root-rot and also to determine the permanency of the improvements in type and habits of growth which have been manifested so far. It seems reasonably certain, however, that definite progress has been made.

Brown Root-Rot. (C. V. Kightlinger.) Brown root-rot causes some damage to tobacco in the Connecticut Valley at the present time and probably would cause much more damage if it were not that the circumstances under which the disease ordinarily occurs are now known and are avoided in large measure in present practices of growing tobacco in the Connecticut Valley. The practices of not rotating tobacco with crops known to produce soil conditions favorable to the development of brown root-rot and of growing tobacco continuously after tobacco for as long a time as may be possible are applicable in the control of the disease where the acreage of tobacco is being maintained or reduced somewhat, as has been the case in the Connecticut Valley during the last few years. This method of control, however, is restrictive and is not always convenient to follow even under present circumstances, but the rather dilligent application of the practice has reduced the prevalence and severity of the disease so that it has been of minor importance economically in the Connecticut Valley during the last several years.

Brown root-rot may become more prevalent and injurious in the Connecticut Valley in case of an increase in acreage of tobacco, because of the necessity of using additional land which, on account of previous cropping, may be in a condition favorable to the development of the disease. If this occurs, it will contravene the only measure for the control of brown root-rot of tobacco which is generally recognized at the present time as being applicable to field use. Therefore, a measure which would control brown root-rot of tobacco satisfactorily under varied circumstances and which would be convenient to use on considerable acreages would mean much to the growing of tobacco in the Connecticut Valley in the event that the acreage is increased. Such a measure would be useful also under present circumstances, especially if it would permit rotation of tobacco with other crops in general.

With this situation in mind, experiments were begun in 1939 to obtain further information on the relationship of soil fertility conditions to the development and to the control of brown root-rot of tobacco. One purpose in particular is to study the effect of certain soil treatments on the fertility levels of the soil and to study the effect of different degrees of fertility of the soil on the occurrence of brown root-rot of tobacco following the crops used in the experiment. It is desired especially to learn whether brown root-rot will develop in tobacco which is grown continuously after tobacco under low fertility conditions of the soil. And finally, in case brown root-rot of tobacco develops as a result of these experiments, another purpose is to study means of hastening recovery.

The arrangement and procedure of the experiments designed to determine whether low fertility of the soil may promote the development of brown root-rot of tobacco, consists of four sets of six one-twentieth acre plots in which tobacco, corn, millet, rye, clover, and timothy–red top mixture are grown in the same

manner, except for differences in the use of fertilizers. On two sets of these plots an application of 10-10-10 fertilizer has been made each spring at the rate of 3000 pounds per acre to the plots planted to tobacco, and 2000 pounds per acre to the plots planted to the other crops, in a manner suitable for fertilizing each particular crop. On two other sets of plots no fertilizer has been used, except nitrate of soda which has been applied to all plots alike at the rate of 400 to 500 pounds per acre, to aid in reducing the fertility level of the soil in these plots. The crops were all harvested and removed from the plots each year according to regular farming practices. In an additional experiment on a quarter-acre plot considerably removed from the other experiments, tobacco is being grown continuously after tobacco without any fertilizer at all being used. No results can be reported at this time.

The control phase of the experiment is contingent on the outcome of the other phase; consequently the details of the control phase are not given here.

Soil Treatments for Tobacco Seedbeds. (C. V. Kightlinger.) Damping-off diseases and weeds are troublesome in tobacco seedbeds in the Connecticut Valley. Consequently treatments for their control are important.

Experimental work to test the effectiveness of spring and fall treatments of seedbed soil by steaming and with formaldehyde, and of fall treatments with chlorpicrin and with calcium cyanamid, was begun in 1940 and continued in 1941. The seedbed used for these tests had been prepared especially for the purpose by inoculating uniformly and heavily with damping-off organisms during the spring of 1940. Evidence that the seedbed was abundantly infested with disease organisms was shown by the damping-off of tobacco seedlings grown during the spring and even into late summer of 1940. Care was taken also to make certain that seeds of the more common weeds of tobacco seedbeds were disseminated evenly throughout the soil.

The steaming was done by the pan method at a steam pressure of about 100 pounds applied for 20 minutes, with the pan kept in place for another 20 minutes after steaming had been discontinued. The spring treatment with formaldehyde consisted of a standard solution made of 1 gallon of formalin to 50 gallons of water, applied at the rate of one-half gallon of solution to 1 square foot of soil surface. The fall treatments were steaming, as described above; formaldehyde solution of standard concentration and double the standard concentration, applied in both cases at the rate of one-half gallon of solution to 1 square foot of soil surface; chlorpicrin, applied at the rate of 2 cubic centimeters per square foot of soil surface, and also at double this rate of application, to a depth of about 4 inches into the soil, by means of commercial applicator commonly used for the purpose; calcium cyanamid, applied at the rate of one-half pound per square yard of soil surface, and also at double this rate. In both cases, the calcium cyanamid was worked into the soil thoroughly, three-fourths of the total amount to a depth of 4 to 5 inches and one-fourth to a depth of about 1 inch. The soil treated with calcium cyanamid and chlorpicrin was of proper moisture content for effective treatment at the time and was moistened daily for several days thereafter. The soil temperature at the time formaldehyde, calcium cyanamid, and chlorpicrin were applied in the fall was 67° F., and changed little for a considerable time following the treatments.

No damping-off of tobacco seedlings occurred during the season of 1941, even in the untreated plots of the seedbed, in spite of the fact that tobacco was seeded at double the usual rate and the bed was watered thoroughly every day, and sometimes oftener, to promote damping-off. The unusually warm, dry weather which occurred during the spring of 1941 was sufficient, apparently, to prevent damping-off in spite of the effort that was made to promote its development.

Consequently the comparative value of the treatments for controlling damping-off could not be determined.

The treatments all gave some control of weeds. There were wide differences, however, in the different treatments and also in different replications of the same treatment, except in the case of steaming, which gave consistently good control in all replications of either the fall or the spring treatments. Some replications of the treatments with calcium cyanamid, chlorpicrin, and double-strength formaldehyde solution applied in the fall gave fairly good control of weeds; but these were largely offset by unsatisfactory control in other replications of the same treatments. Steaming was the only treatment that gave entirely satisfactory control of weeds.

The experiment is being repeated.

DEPARTMENT OF ANIMAL HUSBANDRY

Victor A. Rice in Charge

A Study of the Mineral Elements of Cow's Milk. (J. G. Archibald and C. H. Parsons.) During the winter of 1940-41 the possibility of increasing the manganese content of milk by feeding supplemental manganese was investigated. Eight cows in the college herd were divided into two groups of four each, and fed manganous sulfate (1 ounce daily) by the double reversal system. Monthly sampling and analyses of the milk of the individual cows from November through April, showed that, regardless of group or individual, the feeding of the manganese supplement definitely increased the manganese content of the milk. On the average the amount of manganese in the milk of cows receiving the supplement was just about double that in the milk from cows not receiving it. (46.1 gammas of Mn per liter of milk as contrasted with 23.5 gammas per liter). Advance announcement of this finding has been published in *Milk Plant Monthly*, Vol. 30, No. 9, September, 1941.

Investigation of the Merits of Legume and Grass Silage for Massachusetts Agriculture. (J. G. Archibald and C. H. Parsons.) As a result of comparative trials extending over three years with molasses and phosphoric acid as silage preservatives, this station has discontinued the use of phosphoric acid as a preservative. The reasons for this are:

1. Molasses silage has been definitely more palatable to milking cows than phosphoric acid silage.
2. Molasses costs somewhat less, even when the much smaller amount of phosphoric acid required is taken into consideration.

Work this past year with grass silage has centered chiefly around its effect on milk flavor in contrast with the effect of corn silage. Part of the herd was fed grass silage and another part corn silage, and the schedule was reversed at midseason. Individual milk samples from all cows milking at the time have been taken for a period of three days in each month from November through April and judged for flavor. There are some discrepancies among the results, and the differences are not very marked, but in general the grass silage has produced milk with a higher flavor score and with less incidence and persistence of the common off-flavors. Individual off-flavors most reduced when grass silage was fed were malt, bitter, rancid, and oxidized in the order named.

A Study of Urea as a Partial Substitute for Protein in the Rations of Dairy Cows. (J. G. Archibald.) This project has been actively conducted throughout the year. Results are available from two years of double reversal trials with eight

cows and from a full lactation period of continuous feeding of urea to eight other cows in comparison with a similar group continuously fed the regular herd ration. Final conclusions cannot be drawn until the second year of continuous feeding of urea to the eight cows, just referred to, has been completed, and until at least a year's results are available from a group of cows more recently put onto a control ration containing no urea. This last phase of the investigation has been included in order to check more closely the adequacy of basal protein levels in the ration. All things considered, to date the urea ration seems to be producing results similar to those obtained on the regular ration.

DEPARTMENT OF BACTERIOLOGY

Leon A. Bradley in Charge

Nitrification in Soils Containing Plant Residues of High Lignin Content. (James E. Fuller, cooperating with the Agronomy Department.) During the growing season of 1940 thirteen plots were under observation. During the growing season of 1939 one of these plots had remained fallow, and each of the remaining twelve had been planted with a forage crop. There were no duplicates. Then, in 1940, the whole area was planted with tobacco, after the plant residues of the preceding crop had been plowed under. Soil samples were taken in the spring of 1941, in mid-season, and again after the harvest. The soils were studied for their ability to nitrify their own nitrogen, added dried blood, and added ammonium sulfate, respectively. The results of the nitrification studies were compared with the quantity and quality of tobacco produced on the plots in 1940. There was some evidence, in the dried-blood study, that plots giving less active nitrification gave poorer quantity and quality of tobacco.

The study was repeated on a second field in 1941. The set-up was replicated six times, giving 78 plots instead of the 13 studied in 1940. Results of 1941 have not been analyzed sufficiently to permit any statement at the present time.

Comparative Study of Certain Media Employed for Fecal-Flora Studies. (James E. Fuller and Irwin Fried.) Much of the investigational work on fecal bacteriology, in connection with nutritional studies, is based upon determining the ratio of bacteria of the lactobacillus group to those of the coliform group, because a predominance of lactobacilli is considered desirable for intestinal health. It is desirable, also, to differentiate the members of the coliform group present in order to make a useful interpretation of results.

The present study compared certain media commonly employed to enumerate coliform bacteria. Results were as follows: litmus-lactose agar, brom-cresol-purple agar, and lactose agar with Andrade's indicator were not selective for the coliform group of bacteria, and gave no differentiation within the group. Endo's agar and E. M. B. (eosin-methylene blue) agar gave distinctive colonies of the group and good differentiation, but both produced substantially fewer colonies than lactose agar when plates were made with these three media from pure cultures of bacteria of the coliform group. This indicates that both Endo's and E. M. B. media give low counts of coliform bacteria when they are used in fecal-flora studies. Certain combinations of non-coliform bacteria produced reactions on these media that could be confused with those of the coliform group. MacConkey's bile-salt agar inhibited growth of bacteria of the group to a greater extent than did either Endo's or E. M. B. media, and did not give satisfactory differentiation within the group.

The Bacteriology of Chocolate Syrups, Cocoa Powders, and Chocolate Milk. (James E. Fuller and R. W. Swanson, in cooperation with W. S. Mueller of the Department of Dairy Industry.) Bacteria counts showed wide variation in the numbers of bacteria in the different syrups and powders. Most of the bacteria identified were aerobic sporulating bacteria of the *Bacillus subtilis* group. No Gram-negative bacteria of intestinal type were found, which would indicate that the syrups and powders were free from intestinal contamination. Bacteria of this type inoculated into solutions of the syrups and powders survived only a few days.

Growth of bacteria was not as rapid, nor were the counts as large, in milk with syrups or powders added as in the same milk supply without the addition. Thus, it appears that the syrups and powders had some inhibitory effect on bacterial growth. Further studies indicated that the tannins present in the syrups and powders were responsible for the inhibition. Oxalic acid and theobromine, in concentrations found in chocolate or cocoa, had no apparent effect on bacterial growth. Molds and yeasts appeared to be more active than bacteria in causing spoilage of chocolate milk.

Studies of Methods for Determining the Sanitary Quality of Drinking Utensils. (Ralph L. France, W. E. Cassidy, and James E. Fuller.) Work on this project has been completed, with the following results: (1) A swabbing method is the best for recovering bacteria from the lips of a glass. (2) A wet swab is more efficient than a dry or moist swab. (3) The most satisfactory suspending fluid is one having the following composition: 2.5 cc. of 0.04 M $MgSO_4$, 2.5 cc. of 0.01 M $CaCl_2$, 0.5 cc. of 0.001 M $FeCl_3$, and 1.25 cc. of Butterfield's buffered phosphate solution made up to 1000 cc. with distilled water. (4) The most satisfactory plating medium was one with the following substances: Neopeptone, 10 grams; yeast extract, 5 grams; dextrose, 0.5 gram; NaCl, 5 grams; and agar, 15 grams. The reaction of this medium is adjusted to pH 7.5. (5) Inoculation of a swab, or 1 cc. of a 1/10 dilution of washings from the swab, into dextrose broth frequently revealed the presence of mouth streptococci. This test has considerable sanitary significance when used in conjunction with the count. The addition of potassium tellurite to the dextrose broth failed to eliminate interfering organisms.

The Effectiveness of Certain Detergents and Procedures Employed for the Cleansing of Eating and Drinking Utensils. (Ralph L. France.) Field studies have been made of the methods employed in the cleansing and sanitization of eating and drinking utensils in public establishments throughout this area. Bacteriological examinations indicate that these methods are not satisfactory. Work is being continued on this project.

Laboratory Service. (Ralph L. France.) Following is a list of the types and numbers of examinations made during the past year.

Milk (bacteria counts)		895
Ice cream (bacteria counts)		153
Water		124
Eating and drinking utensils		120
Miscellaneous		106
Butter fat:	71	
Solids:	22	
Mastitis:	12	
Burlap:	1	
Total		1,398

DEPARTMENT OF BOTANY

A. Vincent Osmun in Charge

Diseases of Trees in Massachusetts. (M. A. McKenzie and A. Vincent Osmun.)

The Dutch Elm Disease Problem. For several years in the cooperative program for the study of the Dutch elm disease in Massachusetts, intensive effort has been concentrated in Berkshire County as new stations for the causal fungus, *Ceratostomella ulmi* (Schwarz) Buisman, were reported in nearby New York and Connecticut. During recent years, the circulation of numerous false reports that the disease was present in Massachusetts, and even the publication of photographs of trees removed because they were affected by the disease have sometimes confused and alarmed the public. At least a part of the confusion has resulted from the failure to distinguish between the fungus which causes the Dutch elm disease and the principal carrier insect, *Scolytus multistriatus* Marsh., which is a bark beetle infesting certain areas of Massachusetts, notably southern Berkshire County and the region east of Worcester County.

The spread of the disease into Massachusetts was delayed for several years by the eradication of diseased trees in the adjoining states, although early in 1941 it was pointed out[1] that elms in southwestern Massachusetts were in immediate danger from the encroachment of the disease on Berkshire County from New York on the west and Connecticut on the south. However, in September 1941 the first Massachusetts elm in which the presence of the disease could be officially established, was eradicated—a young tree about 20 feet in height growing on private property in the town of Alford. Typical symptoms of foliage wilting and streaking of the woody parts were present. The Scolytus beetle was not found in the tree but has been observed in the town. In the vicinity of the diseased tree and elsewhere throughout Massachusetts, hundreds of other trees showing symptoms macroscopically indistinguishable from those of the Dutch elm disease were checked in field and laboratory studies during the past year, but no additional trees with the disease have been discovered. The work of the organized project of this Station in collecting and studying specimens from suspected trees has been supplemented by other public and private groups and by individuals, including the Massachusetts Department of Agriculture, the United States Department of Agriculture, the Massachusetts Forest and Park Association, town and city tree wardens, employees of other municipal and state departments, arboriculturists, public utilities, and private citizens.

The most constructive procedure in attempting to check the spread of the disease is the removal of all elm material in such a condition as to be attractive to carrier beetles. The quantity of such material present in any location may be related to a number of factors, as in southern Berkshire County where drouth injury and repeated attacks of leaf-chewing insects have seriously weakened many elms in such a manner as to make them suitable for infestation by beetles; and the destruction of this material will doubtless prove of inestimable value in limiting the population of carrier beetles of the Dutch elm disease fungus.

Other Tree Problems. Sixty-nine diseases of thirty-four species of trees, including eleven diseases of elm were identified from more than 500 specimens and inquiries received during the year. The Cephalosporium wilt of elm was reported from 21 municipalities in which no previous cases of the disease were reported,

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[1]McKenzie, Malcolm A. The Dutch elm disease problem in Massachusetts. Published in "Progress Report including Transcriptions of Certain Papers presented at the Eighth Annual Five-Day Short Course for Tree Wardens and Other Workers with Trees," M. S. C., March 28, 1941.

making a total of 173 cities and towns in which the disease has been found in Massachusetts. Also, a fungus, *Verticillium* sp., was isolated from elms in 8 communities in which it was not previously known, and reports show a total of 96 municipalities in which this fungus has been found in woody plants in Massachusetts.

The extended period of dry weather during the summer of 1941 was a serious cause of tree injury, and therefore, additional trouble associated with winter injury may be expected from this source next year, especially in the case of evergreens, which commonly experience winter injury even in years of normal rainfall.

Because of outbreaks of elm pests during the summer of 1940, a circular[2] was prepared this year and distributed to meet the demands for information on the subject.

A disease known as bleeding canker of hardwoods has been reported to be increasing in New England and, at least under certain conditions, the writers have seen cases in which attempted remedies have caused more damage than the fungus. A fungus, *Phytophthora cactorum*, has been described[3] as the cause of the disease, and an organism believed to be the same fungus has been isolated by the writers from elm, maple, beech and oak in Massachusetts, although evidence of serious disease in the host was not always conspicuous. A possible injection treatment employing "Helione Orange" and requiring skilled technicians has been described[4] following preliminary experimental work. Critical evaluation of the results may be possible at some later date; for the present, however, specific recommendations cannot be made.

Current miscellaneous activities of the project included the preparation of parts of the program of the annual Five-day Short Course for Tree Wardens, the compiling of a progress report,[5] the discussion of wood-destroying fungi[6] at the Eastern Pest Control Operators' Conference, and the preparation of newspaper press releases.

The Importance of the Investigation of Tree Diseases in National Defense. In this brief outline of phases of the project which have expanded in relation to national defense, it should be pointed out that it is not possible to distinguish sharply between basic and emergency activities. In fact, none of the following activities are completely new to the project, but increased demands on the part of the public have been classified under three arbitrarily selected groupings among which there is considerable overlapping.

1. Housing projects, new real estate developments, and increased prosperity in general have resulted in increased interest in trees and tree diseases around homes and along streets and highways.

2. As lumbering operations near the point of demand for wood have increased, owing to the necessity for curtailment of transportation costs, supply of labor, shortage of materials, etc., certain types of forest-tree diseases have increased both in the forest and in nearby ornamental trees. The practice of cutting only mature forest trees as a crop maintains a highly desirable, relatively stable biological balance, but only about 5 percent of the nation's forests are operated on this basis in normal times and no hope for an increase in yield-basis operations can be held in the present emergency.

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[2]McKenzie, M. A., and Becker, W. B. Timely spraying protects elms against midsummer defoliation. Amherst, 1941.

[3]Howard, F. L., and Caroselli, N., Phytopathology 30:11. 1940.

[4]Howard, F. L. Science 94:2441:345. October 10, 1941.

[5]Transcriptions of certain papers presented at the eighth annual five-day short course for tree wardens and other workers with trees. Amherst, March 24-29, 1941.

[6]McKenzie, M. A. Wood decay fungi, published in the "Proceedings of the First Annual Eastern Pest Control Operators' Conference," Amherst, January 13, 14, and 15, 1941.

3. Fungus attack on trees does not end when the tree becomes lifeless wood, although proper seasoning and protective treatment will greatly prolong the life of wood in service. Because of the neglect to consider damage from wood decay fungi and related factors, extensive damage to wooden structures has already been observed and additional trouble may be expected.

For the most part, it is common knowledge that tree disease investigations are essential for defense, but the importance of constant vigilance against tree diseases has been stressed[7] in connection with work on tree problems during 1941. Insidious inroads on public wealth by disease fungi would be rampant if the prosecution of essential disease investigations were relaxed in favor of what, for a thought'ess moment, might appear a greater defense priority need. Disease investigation is primary, vital defense, and in retrospect it is basic to the strong position which this nation holds today.

Damping-off and Growth of Seedlings and Cuttings of Woody Plants as Affected by Soil Treatments and Modification of Environment. (W. L. Doran.) An Experiment Station bulletin on some of the more immediately useful results of work done under this project has been published[1] and is now in considerable demand.

Work on the vegetative propagation of white pine is being continued. Cuttings rooted in larger percentages and responded more to treatments with root-inducing substances, if they were made with the basal cut at the base of the current year's wood rather than at the base of wood two years old. They rooted better in sand-peat or sand than in sandy soil, and, in one experiment, treated cuttings rooted better in sand than in sand-peat. Best results with January cuttings, 67 percent rooting, were obtained from treatment with indolebutyric acid (200 mg./l., 5 hr.), but there was 58 percent rooting of cuttings treated with naphthaleneacetic acid (100 mg./l., 4hr.), and only 13 percent rooting of the untreated cuttings. Results were less good if cuttings were taken in summer, fall, or earlier in the winter.

Much attention was given to the rooting of cuttings of hemlock and a paper was published[2] on that subject. Cuttings of hemlock, taken in November, rooted best, 100 percent in fourteen weeks, after treatment with indolebutyric acid (100 mg./l., 24 hr.), but naphthaleneacetic acid was also very effective and there were indications that it is sometimes even more effective than indolebutyric acid. Results obtained justify the suggestion that propagators working with late-fall cuttings made of wood of the current year make some use of naphthaleneacetic acid although, with cuttings made with the basal cut at the base of wood two years old, indolebutyric acid in relatively high concentrations was very effective.

A note was published[3] on the rooting of cuttings of umbrella-pine, another species which is usually considered difficult to propagate in this way. They failed to root or to root at all well, treated or not, if taken in September or October; but if taken in January, they rooted 92 percent after treatment with naphthaleneacetic acid (100 mg./l., 2 hr.), decidedly less well if treated with indolebutyric acid. Rooting of December cuttings of *Poncirus trifoliata* was also much more improved by naphthaleneacetic acid than by indolebutyric acid, and lilac cuttings responded better to naphthaleneacetic than to indolebutyric acid. But

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[7]McKenzie, Malcolm A. Municipal shade tree problems in national defense. Published in "Proceedings of the Annual Meeting of the Mass. Tree Wardens' Assn.," February 13, 1941.

[1]Doran, William L., The propagation of some trees and shrubs by cuttings. Mass. Agr. Expt. Sta. Bul. 382, 56 pp. 1941.

[2]Doran, William L. Propagation of hemlock by cuttings. Amer. Nurseryman 74: 6: 18-19. 1941 (Contribution No. 413.)

[3]Doran, William L. Propagation of umbrella-pine by hormone-treated cuttings. Florists Exchange 97:9:9. 1941. (Contribution No. 414.)

indolebutyric acid gave much better results with cuttings of Hinoki cypress than did naphthaleneacetic acid.

Untreated cuttings of *Clematis lanuginosa* var. *candida* and the Clematis variety Ramona rooted at least 80 percent if taken in mid-July, less well if taken a month earlier or later, and their rooting was not markedly improved by treatment with indolebutyric acid.

Cuttings of *Daphne Cneorum*, taken in July, rooted 75 percent without treatment, more than 90 percent after treatment with Hormodin No. 1, and less well than the checks if treated for several hours with solutions of root-inducing substances or with water only.

Up to 24 hours' treatment with water, only, did not affect rooting of hardwood cuttings of *Juniperus communis* var. *stricta*, *Ilex crenata* var. *Helleri*, hemlock, or mock-orange.

Best results with these cuttings of mock-orange (100 percent rooting in five weeks) followed treatment with Hormodin No. 3. Cuttings which were given a short (six hours') treatment with naphthaleneacetic acid rooted more slowly although also to the extent of 100 percent, a decided improvement over results with untreated cuttings for they rooted only 58 percent.

Cuttings of the Rhododendron variety Cunningham's White developed better roots if treatment with a sugar solution (3.0 percent) followed treatment with indolebutyric acid. But treatments with sugar solutions, whether applied before, after, or with root-inducing substances, failed to increase the percentages of rooting of fall cuttings of that plant or of *Gordonia* and *Daphne Cneorum*.

Study of Diseases of Ornamental Herbaceous Plants, Caused by Soil-Infesting Organisms, with Particular Attention to Control Measures. (W. L. Doran.) Formaldehyde properly diluted may, it was found, be applied safely and effectively to soil immediately after seeding without determining the exact rate of application of the solution to each square foot of soil surface. That, however, is most commonly 1 to 1½ pints per square foot. Formaldehyde, so applied to soil immediately after seeding that each square foot received 2 cc. of it, controlled damping-off of Delphinium, Viola, and sweet pea well and equally well whether each square foot received 0.75, 1.25 or 2.0 quarts of the solution.

Formaldehyde, 4.9 cc. (1 teaspoonful) in 1 gallon water or, what is the same thing, 1 tablespoonful in 3 gallons, gave perfect and safe control of damping-off of Nemesia, columbine, Zinnia, China aster, hollyhock, Phlox, Nicotiana, Verbena, Lobelia, and two species of Dianthus when it was applied to soil immediately after seeding without determining exactly what volume of the solution was applied per square foot. This method[1] is noteworthy for its simplicity, since there is no working of chemicals, such as dusts, into soil, no waiting, and, because soil must usually be watered immediately after seeding, not a single additional operation is involved.

When formaldehyde 0.5 teaspoonful in 1 gallon of water was thus applied immediately after seeding, it gave fair but less complete control. If this very dilute solution of formaldehyde was applied more than once, that is immediately after seeding and again once or twice or three times more at intervals of two days, there was injury to Scabiosa by three applications, not by two, and to China aster by four applications, not by three. But results with these repeated applications were not promising, for damping-off was just as well controlled by one application immediately after seeding.

Formaldehyde applied to soil not previously disinfected improved the growth of Calendula, Zinnia, and China aster. But when formaldehyde (2 cc. per square

[1]Doran, William L. A simple control of damping-off. Florists Exchange 96:21:10. 1941. (Contribution No. 408.)

foot) was applied to soil which had been steamed five days previously, there was some injury, as compared with growth in steamed soil, and there was certainly no improvement in growth as compared with growth in untreated soil. It is concluded that the stimulatory effect of formaldehyde on growth is due principally or wholly to its freeing the plants of the retarding effects of parasitic soil fungi, and it is concluded further that formaldehyde may be dangerous, as regards its effect on some plants, if applied to soil recently steamed.

Spergon (2.7 gm. per square foot) gave fair control of a root-rot of sweet pea seedlings when applied to soil one day before seeding, and there was no injury. But it gave no protection if seeds were sowed thirty days after soil treatment.

Copper oxylate applied to the surface of soil after seeding failed to prevent damping-off of any species.

Semesan (1.1 gm. in 1.2 quarts water per square foot), applied to the soil surface before seeding but not worked into the soil, was not injurious, controlled damping-off fairly well although not completely, and increased by 27 to 100 percent the numbers of seedlings of marigold, Scabiosa, pansy, and sweet pea which lived. Results were less good when the dry Semesan was worked into the soil, for it was then apparently not sufficiently concentrated near or at the soil surface.

Chemical Soil Surface Treatments in Hotbeds for Controlling Damping-off of Early Forcing Vegetables. (W. L. Doran, E. F. Guba, and C. J. Gilgut.) Especial attention was given to the possible use of ammonium hydroxide and ammonium sulfate as soil disinfectants.

Ammonium hydroxide, 12 cc. per square foot of soil surface, controlled damping-off fairly well and without significant injury to seedlings of beet, although seeds were sowed within five days after soil treatment. However, 16 cc. ammonium hydroxide gave better control although, for safety, it was necessary to wait about seven days before seeding.

Ammonium sulfate had little or no fungicidal effect in acid soils, with pH values of 5.0 to 6.0, but it had a decidedly fungicidal action in soil which, as a result of the earlier use of hydrated lime, had a pH value of about 7.0.

When ammonium sulfate and hydrated lime, one part of the former and two parts of the latter by weight, were intimately mixed and this mixture (at the rate of 10 gm. ammonium sulfate per square foot) was worked into moist soil, there was a strong odor of ammonia and damping-off was well controlled. It was, however, necessary on grounds of safety to wait more than five days after soil treatment before seeding.

Hydrated lime alone, applied to soil, usually increased the number of plants which lived and reduced the severity of damping-off, but the disease was not controlled to any such degree as it was by ammonium sulfate and hydrated lime applied together.

Control of Greenhouse Vegetable Diseases. (E. F. Guba, Waltham.) Approximately 30 percent of the greenhouse tomato growing area in the fall cropping season of 1941 was planted to the Bay State tomato, developed for resistance to Cladosporium leaf mold from hybrids of *Lycopersicum pimpinellifolium* × *L. esculentum*. The new tomato was released for trial in 1939. In the fall cropping season of 1940 a new physiologic form of the fungus, to which Bay State is completely susceptible, was noted at Swansea, Bristol County. In 1941, other instances of the complete susceptibility of Bay State to the new form of Cladosporium were observed. Globelle (Ohio) and Vetomold (Ontario) likewise developed for resistance to Cladosporium, and derived from red currant, have shared the same experience. The new physiologic form of the fungus is infectious to *L. pimpinellifolium* (Jusl.) Mill. and *L. hirsutum* Humb. & Bonpl., causing

yellowish infection flecks and ultimately necrosis. On the lower surface of the spots, under moist conditions, the fungus sporulates rather freely, although it is much less virulent on Bay State than the original prevalent form of the fungus. Both *L. pimpinellifolium* and *L. hirsutum* show a high immunity reaction to the original physiologic form of Cladosporium. *L. peruvianum* (L.) Mill. is immune to both physiologic forms but *peruvianum* will not hybridize with *esculentum*.

Causes and Control of Decay of Squash in Storage. (E. F. Guba and C. J. Gilgut, Waltham.) Gourds instead of squash were treated with various disinfectants and chemical coatings after harvest to determine to what extent these treatments influence keeping. The organisms causing decay of squash similarly attack gourds and the results from such treatments are generally applicable.

The merit of spraying gourds with Bordeaux mixture 4-4-50 and 1 pound calcium arsenate during the growing season was investigated, although it is recognized that the spraying of squash is difficult. The results indicate that fungicidal field treatments result in less decay after harvest and that the progress of decay is further inhibited by coatings of shellac. The value of disinfection between harvest and storage is not clearly shown. A dry ventilated storage following protection in the field with Bordeaux mixture and calcium arsenate was definitely advantageous in the control of decay.

It is apparent, particularly as the result of this season's work with gourds, that considerable infection responsible for decay in storage may take place in the field, without being evident at harvest.

Gardenia Stem Canker. (C. J. Gilgut, Waltham.) It was determined from a histological study of gardenia cankers that the hyphae of the infecting fungus, *Phomopsis gardeniae* Hans. & Scott, are confined to the discolored bark and wood of the cankered section of the stem. Cuttings taken from diseased plants and from healthy plants did not become infected when propagated side by side in clean sand, nor did plants from these cuttings become cankered when grown in greenhouse benches.

Disease Resistance and Heredity of Carnations. (E. F. Guba cooperating with H. E. White, Waltham.) Approximately 75 varieties of carnations have been studied for their reaction to fungus wilt diseases. Also, growers have indicated the performance of a long list of varieties in relation to these diseases under their respective growing conditions. In a compilation of these reports and tests, it is apparent that certain carnation varieties have rather consistently maintained healthy growth. The wilt diseases under consideration in this study are caused by *Alternaria dianthi* (blight), *Rhizoctonia solani* (stem rot), *Fusarium dianthi* (branch rot) and *F. avenaceum* and *F. culmorum* (stem and root rot), and are not equally prevalent. Frequently, only one of these diseases may be troublesome year after year in the same establishment. Twenty-six varieties showing the greatest promise as sources of disease resistance under natural conditions have been selected for further study. The reactions of these varieties to each wilt disease in so far as available will be more carefully scrutinized under more favorable conditions for disease and artificial methods of inoculation before hybridization studies are undertaken. The results of this program should determine the nature, justification, and direction of further effort in the development of desirable disease-resistant types of carnations.

Miscellaneous Tests and Experiments. (E. F. Guba and C. J. Gilgut, Waltham.)

1. *Apple Scab Control.* Ground and chemically prepared sulfurs of a maximum particle size of 50 and 3 microns respectively were compared on an equivalent sulfur basis, and in combination with lead arsenate, and lead arsenate and

lime, for loss of sulfur by weathering, for scab control, and for chemical injury. There were no apples to harvest from the untreated row because of a complete June drop caused by the plum curculio. In this row 20.3 percent of the leaves were scabby and only a small amount of this was primary infection. In the sprayed rows, irrespective of whether the sulfur was coarse or fine, there was no scab.

The results confirm the work of previous years to the effect that sulfur particle size and concentration of sulfur are not as important in scab control as good spraying. Chemical determinations of the residues after spraying revealed that the loss of sulfur by weathering was greater with Magnetic Spray Wettable Sulfur than with dry wettable Flotation Sulfur, early in the season. In both cases more sulfur was retained on the foliage when the combination of sulfur and lead arsenate was used without lime. Fish oil added to Flotation Sulfur, lead arsenate, and lime increased the deposit and retention of sulfur. No improvement was shown by substituting Soya flour for fish oil in the first and second cover sprays. No consistent benefit in the deposit and retention of sulfur otherwise could be shown with the types of sulfur used by the addition of Soya flour.

2. *Copper Dusts for Cucumber and Muskmelon.* Fifteen proprietary and two home-mixed copper dusts containing different sources of metallic copper were tested on cucumber and muskmelon planted in rows of 5 hills of 5 plants per hill. The copper content of the dusts varied from 4.75 to 7 percent. Some contained an insecticide (either 20 percent cryolite, 0.75 percent rotenone, or 5.75 to 10 percent calcium arsenate) added for the control of striped cucumber beetles. The dry summer was unfavorable for the usual foliage diseases, but bacterial wilt and mosaic were present on cucumber.

A proprietary dust containing 5 percent metallic copper and 20 percent cryolite was injurious to both muskmelon and cucumber. On the basis of plant condition and yield, the five best treatments on cucumber were:

6 percent Cu in tri-basic copper sulfate and 0.75 percent rotenone
6 percent Cu in tri-basic copper sulfate
5 percent Cu in copper oxychloride sulfate and 1 percent rotenone
7 percent Cu in tri-basic copper sulfate and 0.75 percent rotenone
5.16 percent Cu in red copper oxide and 0.75 percent rotenone

The best treatments on muskmelon were:

6.5 percent Cu in tri-basic copper sulfate and 0.75 percent rotenone
6.5 percent Cu in tri-basic copper sulfate and 10 percent calcium arsenate
6 percent Cu in tri-basic copper sulfate and 0.75 percent rotenone
5.16 percent Cu in red copper oxide and 0.75 percent rotenone
5 percent Cu in copper oxychloride sulfate and 7.5 percent calcium arsenate
4 percent Cu in copper hydroxide and 7 percent calcium arsenate

The differences between the best copper treatment combinations and a 0.75 percent rotenone dust on muskmelon were not significant in 1941.

3. *Mercury Compounds for Control of Club Root of Crucifers.* In a preliminary exploratory experiment calomel and mercuric bichloride in varying amounts were used for the control of club root of cabbage and cauliflower. Applications were made to seed flats and in the field at different times and by various methods. Because of uneven infestation in the experimental block, the results were indefinite and no conclusions can be made.

4. *Vegetable Seed Treatments for Damping-off Control.* For the second successive year cooperative tests of vegetable seed treatments were conducted under the auspices of the committee for coordinated seed treatment research of the American Phytopathological Society. Weighed amounts of treated seed (treat-

ment based on weight of seed) were furnished to the cooperators by the committee. Five replications of 100 seeds for each treatment and no treatment were counted and planted in randomized blocks.

With cucumber, there was no significant difference between treatment with 0.25 percent red copper oxide, 0.75 percent Semesan, and no treatment. Treatments with 2 percent red copper oxide, 2 percent zinc oxide, and 0.2 percent Semesan showed no significant differences with celery; but with lettuce 2 percent red copper oxide and 2 percent zinc oxide were significantly better, in the order given, than no treatment. With sweet corn, 2 percent red copper oxide, 2 percent zinc oxide, and 0.2 percent Semesan Jr. were no better than no treatment. Cabbage was distinctly benefited by 2 percent zinc oxide and 0.2 percent Semesan. From seed treated with hot water and subsequently with chemical dusts, the stands were reduced, yet they were better than stands from seed treated only with hot water.

The value of a number of dry chemical powders in preventing pre-emergence damping-off and seed decay of lima beans was determined. Spergon-treated seed produced a larger number of seedlings and consequently a greater yield of lima beans than seed receiving any other treatment or no treatment. The second best treatment was red copper oxide, which held a slight advantage in number of seedlings and yield over zinc oxide. Semesan was distinctly injurious to the seedlings, the injury persisted throughout the growing season, and the yield was materially reduced. Although more seedlings grew from seed treated with Semesan than from untreated seed, the total yield from untreated seed was nearly twice that from Semesan-treated seed.

Effect of Vitamin B_1 at Different Soil Temperatures on Gardenia Chlorosis. (L. H. Jones.) Gardenia plants became chlorotic at soil temperatures of 55°, 60°, and 65° F. The soil was treated weekly with a solution of thiamin chloride (vitamin B_1), one part in ten million, used at a temperature equal to the soil temperature. The plants were replicated in sufficient containers so that the thiamin chloride could be applied before, at the observable period when, and after chlorosis appeared. There was no noticeable evidence that thiamin chloride at this concentration could prevent chlorosis induced by low soil temperatures or cure a gardenia plant so affected.

In a later test with chlorotic plants, soil treatment with 100 times the above concentration (1 part in 100,000) did act as a mild remedial measure. New leaves at the unfolding stage were dark green in color, old leaves had the yellowing between the veins supplanted with a healthy green color, and basal shoots developed with dark green foliage. Since this effect took place at about the time of the vernal equinox, it appears that this concentration of thiamin chloride hastened what would have occurred normally a short time later. Since the temperature of the solution when applied corresponded to the soil temperature, the results must be ascribed to the use of vitamin B_1.

The Effect of Soil Temperature on Growth. (L. H. Jones and J. W. Hall.) Corn, tomato, and rose were used as indicator plants. When soil temperatures were altered to 55°, 60°, 70°, 80°, and 90° F., plants which were established in the soil at 75° showed marked effects of temperature on development over a period of 78 days. There was poor growth and no flowering of corn, tomato, and rose plants at soil temperatures of 55° and 60°, but at 70°, 80°, and 90°, the plants grew vigorously and flowered. Corn and rose plants did best at 90°, while the tomato, John Baer, apparently was at its optimum environment at a soil temperature of 80°. Internode length in corn increased up to a soil temperature of 70°, while the internodes of the tomato plant were longest at 80°. The air tem-

perature was maintained at about 80° F. The resulting differences in vegetative and reproductive development are, therefore, attributable directly to soil temperatures.

The Effect of Root Media on Root Structure. (L. H. Jones and B. Eames.) Soybean and corn plants grew equally well in either sand or solution culture and could be shifted from one medium to the other without any drastic effect on the root system. Roots in sand cultures were thicker and kinked as compared with the slender, smooth roots grown in solution. A study of the root structure before and after transfer from one type of medium to the other did not disclose any particular modification of root structure other than an increase in the amount of cortex in roots developed in the sand medium.

Geranium cuttings, rooted in sand and transferred to a solution medium, developed new roots at the callus above the level of the solution, the original roots dying in the solution. On the other hand, chrysanthemum cuttings were able to continue growth without the necessity of producing a new set of roots, the original roots being able to function when transferred from sand to a solution.

DEPARTMENT OF CHEMISTRY

W. S. Ritchie in Charge

Analytical Service. (The Department.) Many of the analytical services, formerly performed by the department, have been taken over by the Control Laboratories.

The analysis of various blueberry bushes, particularly for iron and manganese, from an "elemental" fertilizer experiment have been completed for the Department of Pomology.

Samples of a lubricating oil and fungicides have also been examined.

Testing Analytical Methods. (E. B. Holland.) The work of several years on a method for the determination of zinc in foodstuffs has been completed, and the procedures appeared as a part of bulletin 379 of this Station.

A study of the method for the determination of fluorine in insecticides has been started, and will receive additional attention during the coming year.

The Iron, Copper, Zinc, and Iodine Content of Fruits and Vegetables. (E. B. Holland, C. P. Jones, and W. S. Ritchie.) During the past several years a large number of foodstuffs for both man and beast have been collected, and analyzed for the above elements, as well as for approximate analyses. The results have been classified and tabulated, and published as bulletin 379 of this Station.

Lignin and Its Relation to the Absorption of Minerals by Plants. (Emmett Bennett.) This project is being continued in much the same way as outlined previously in other reports. Derivatives of lignin have been prepared. Attempts are being made to fractionate these compounds and correlate such fractions with certain properties of lignin. Limited data do not warrant conclusion at this time.

Hemicelluloses. A preliminary attempt is being made to obtain and characterize the hemicellulose fractions of several different species of grass, with the hope of being able to correlate such differences as may exist with differences in species composition. Extractions have been completed and some fractions have been isolated, but as yet no data have been obtained regarding species differences.

Chemical Investigation of the Onion. (Emmett Bennett). One paper on the effect of storage of the Ebenezer onion has been published in Volume 39 of the Proceedings of the American Society for Horticultural Science.

A preliminary examination of the soluble carbohydrates indicates that the reducing sugars are probably glucose and fructose. This indication is substantiated by the formation of osazones characteristic of these sugars and by the products of oxidation produced by iodine. According to the latter test the non-reducing sugars are composed of approximately one third aldose sugar and two thirds ketose sugar. This general distribution is to some extent substantiated by the polariscopic behavior of solutions of the mixed sugar fractions. Prior to inversion the optical rotation is usually slightly negative. After hydrolysis the optical activity is decidedly more negative. Such response is usually indicative of an inulide fraction. Further identification of these carbohydrate groups by means of definite derivatives has not been successful. Analytical methods for other compounds concerned with the several phases of the project have also been evaluated.

Chemical Changes in the Cooking Quality of Vegetables. (Monroe E. Freeman and W. S. Ritchie.) A new technique for estimating the texture of cooked potato tissue was reported in the annual report for 1940. This technique has been developed into a quantitative method based on the observation that mealy tissue becomes porous on drying while waxy or soggy tissue becomes non-porous. The pore volume of dried slices of tissue can be measured quantitatively by weighing the samples under toluene when the pores are filled with air and when filled with toluene. From these data the weight percent of toluene filling the pores can be calculated and used as an index of texture. The samples were thoroughly dried (in vacuo over P_2O_5), weighed in air and then under toluene. The weight of the sample under toluene with all the pores filled with toluene was calculated from the predetermined density of the potato dry matter and the density of the toluene. Toluene indices ranged from 0.15 to values as high as 6.30 percent and were easily reproduced within experimental error of ± 0.05 to ± 0.10 percent.

The method was carefully checked by determining the specific gravity of a large number of tubers, baking them, estimating the mealiness by personal judgment, and measuring the toluene index. In all cases there was very satisfactory agreement among these methods for estimating texture. Specific gravity and judging method for texture estimation are rapid but distinguish only four or five grades of texture. Toluene index is a longer and more technical method but it has the distinction of offering a quantitative measure of potato texture or cooking quality and therefore offers a great advantage to research workers in this field.

A storage experiment on potatoes is now under way to demonstrate the applicability of this research tool. Samples of tubers are being stored at 35° and 50° F., and in commercial storage. Samples will be withdrawn at intervals and the texture measured by the three methods as above.

Physico-Chemical Properties of Starches. (Monroe E. Freeman.) Very little accurate information is available regarding the chemical and physical properties of the different starches that control the properties of manufactured dextrins, because the industry is operated largely as an art or a craft. The introduction of precise scientific control can undoubtedly be facilitated by the accumulation of data on (a) the chemical and physical properties of the starches, (b) the conversion process itself, and (c) the chemical and physical properties of the dextrins.

Experimental apparatus has been designed, constructed, and tested that intimately mixes a fine spray of acid with a dust cloud of starch. Moisture con-

tent, concentration, and rate of flow of acid and starch can be regulated. An electrometric titration method for measuring small concentrations of acid in starch has been satisfactorily worked out. Apparatus for heating the acidified starch under thermostatic control, uniform agitation, and a controlled atmosphere of air, carbon dioxide, or nitrogen has been designed and constructed.

There exists a real need for an adequate description or definition of the different grades and types of modified starches. This problem has been approached by studies on the physical and chemical properties of commercial dextrins. Analyses for moisture, reducing sugar, copper-reducing power, alkali lability, solubility, iodine color, ash, bound water are in progress on a series of commercial samples and their fractions. Characterization of dextrins by the ratios of significant fractions is also under investigation. Several dextrins have been fractionated by alcohol and the dextrin acetates have been fractionated by organic solvents. Characterization of the dextrin fractions is being carried out by end group assays and viscosity–molecular weight determinations.

Studies of the physical and chemical properties of the starches have begun with an examination of the phosphorus content of several starches. An electrodialysis technique was developed for quantitatively measuring the inorganic and the organically bound phosphorus in natural starches and in phosphorylated starches. Since size of starch grains is believed to be a factor influencing the character of the manufactured dextrins, a grain size classifier for separating large-grain and small-grain fractions has been designed. Since water relations play an important role in the conversion of starch, studies have been continued on the bound water and free water relationships.

Several methods for determining the bound and free water ratio in starch have shown that potato starch suspensions contain about .3 gram of bound water for each gram of dry starch. Canadian and Russian workers have reported anomalous heat capacities for suspension of hydrophyllic colloids and these data were interpreted as indicating a lower specific heat for bound water thus affording a new method for measuring the bound water. Similar data were collected in this laboratory for starch water suspensions. Careful analysis of the data, however, shows definitely that the above interpretation is erroneous. The anomalous behavior of the starch water suspensions can be accurately described by linear equations embracing a discontinuity at the point where all the water in the starch suspension is bound. An explanation of this phenomenon is awaiting verification by experiments on other systems of hydrophyllic colloids.

Investigations on the Nutritive Value of Fishery Products as Human and Animal Food. (Monroe E. Freeman and W. S. Ritchie.) The Progressive Decomposition of Fish Muscle. Studies on the first stages of protein decomposition in fish muscle (Annual Report—1940) were followed by investigation of more extensively decomposed muscle tissue. About twenty-five different fractions were isolated as picrate derivatives from one large sample of haddock muscle. None of these compounds nor their derivatives exhibited clearly defined melting points. Consequently their identification depends on ultimate analyses for carbon, hydrogen, and nitrogen; and determination of molecular weights. Since many of these picrates are violently explosive, special techniques have been devised to facilitate semi-micro combustion and Dumas analyses.

The Influence of Base Exchange Capacity and of Exchangeable Ions in Massachusetts Soils on the Availability of Potassium. (Dale H. Sieling.) As a forerunner to the actual investigation of soils collected for this study it seemed advisable to use the soils most readily obtainable in large quantities for physiological

tests with plants. This was done by varying the base exchange capacity and the calcium–hydrogen ratio of the soil artificially over the range of these values observed for the other soils. It was thought that this method of approach would establish certain facts that might then be confirmed by using the naturally occurring soils for similar tests.

The basic soil used in these tests was classified as Agawam fine sandy loam. It had a pH of 5.7, an exchange capacity of 7.13 M. E.* per 100 grams and an exchangeable calcium content of 2.91 M. E. per 100 grams. The material added to the soil to vary the base exchange capacity was electrodialyzed bentonite, an inorganic colloidal material having a base exchange capacity of 73.5 M. E. per 100 grams. The calcium–hydrogen ratios of both the soil and the electrodialyzed bentonite were adjusted to the desired values by liming with calcium hydroxide. The base exchange capacity at any desired calcium–hydrogen ratio was varied between the value for the soil and that for the bentonite by mixing the two constituents.

Pot cultures were prepared by this method which varied in reaction from pH 5.7 to 7.15 and in base exchange capacity from 7.13 to 13.16 M. E. per 100 grams of soil. Phosphorus, potassium, magnesium, and nitrogen were kept constant in the various cultures by adding weighed quantities of the salts of these materials. Duplicate series of pot cultures, with and without added boron, were prepared to check the influence of calcium level and pH on the occurrence of boron deficiency—a condition often associated with "over-liming."

Four tobacco seedlings (Kightlinger's No. 211), five weeks old, were transplanted in each culture. The cultures were watered daily with distilled water and after two weeks three of the four plants of each culture were removed. The remaining plants were grown for a total of eight weeks and then harvested by cutting each plant off at the soil surface. The plants were dried at 60° C. and the dry weight was recorded. The dried plants have been stored and will be analyzed for potassium to see if there was any appreciable difference in the uptake of that element.

During the growing season nitrogen deficiency developed in the plants of some of the cultures even though this element was added from time to time. It seems quite likely that insufficient nitrogen was supplied in the cultures. From the appearance of the plants there was not a lack of boron in any of the cultures or at least there was enough to prevent deficiency symptoms from occurring regardless of the reaction of the soil or its calcium level. The dry weights of the plants were not greatly different although there was a tendency for the dry weight to decrease at any pH as the exchange capacity and the calcium level increased. This observation was most pronounced at pH 5.7. Since nitrogen deficiency was observed in most of the cultures it seems logical to believe that variations in growth or potassium utilization due to calcium–hydrogen ratio or base exchange capacity would be minimized.

These same cultures will be used to grow a second crop during the summer of 1942, with the hope of gaining more information about the influence of these various factors on plant growth and the utilization of potassium by plants.

The Relationship of Base Exchange Capacity, Exchangeable Hydrogen, and Soil Reaction to the Lime Requirement of Massachusetts Soils. (Dale H. Sieling.) Samples of the various soils obtained for determining the relationship between lime requirement and the exchange capacity and exchangeable hydrogen were limed with increasing quantities of calcium carbonate. Conditions of liming were established to simulate the actual conditions in the field by placing the soils on top of a layer of sea sand in lacquered metal cans perforated at the bottom.

*M. E. = milli-equivalent.

This system allowed for drainage of the soils and also the actual determination of the pH of the soils in place. The soils were limed at a rate of from 125 to 1000 pounds of calcium carbonate per acre-inch, based on previously determined volume weights of the soils as they were found in the field.

The reactions of the soils of each series, variously limed, were determined at regular intervals. The soils were wetted with distilled water and allowed to stand overnight to permit drainage of the excess water and the removal of nitrates that may have accumulated as a result of bacterial action. The pH values were determined in duplicate samples of soil dampened with water and with saturated potassium chloride. The pH values obtained with the use of potassium chloride were considerably lower than those obtained with water. The amount of lowering of the pH value due to the presence of the salt showed a relationship to the exchangeable hydrogen content of the soil. The indications are that, in general, soils of higher exchange capacity require greater quantities of lime for neutralization than do soils of low exchange capacity at the same initial reaction. The data obtained have not been sufficient to establish any quantitative relationship between the exchange capacity, the initial reaction, and the lime requirement.

Similar experiments set up under field conditions in the localities from which the soils were obtained gave results parallel to those found in the laboratory, except with the two soils which had received a large quantity of commercial fertilizer for growing onions. It is believed that fertilizer produced a lowering effect on the reaction similar to that observed when potassium chloride was added to the soil under laboratory conditions.

Soils having higher base exchange capacities than those obtained originally for these tests have been secured and will be tested in a similar manner.

The Effect of Orchard Mulches on the Plant Nutrient Elements in the Soil. (Dale H. Sieling and J. K. Shaw.) The objectives of this experiment are to investigate the influence of mulching on the accumulation and movement of nutrient cations and of phosphates in an orchard soil and to study the effects of mulching on the trees.

Six mature McIntosh apple trees which had been fertilized with complete fertilizer for the past ten years and had been cultivated during that time were selected for this study. Three separate plots consisting of two trees each were treated as follows: Plot 1 received an application of 290 pounds of hay per 1600 square feet and will be mulched from time to time with hay of known mineral composition; Plot 2 received Fiberglass wool of 2-3 inches in thickness; and Plot 3 was left fallow and will be cultivated in the usual manner.

Soil samples were taken at two systematically located positions under each tree before mulching was started. At each sampling location four samples were taken at specified depths so that any movement of mineral nutrients resulting from mulching might be detected when further samples are obtained and analyzed.

The samples of soil were stored in sealed glass jars to prevent loss of moisture and the subsequent fixing of potassium and other mineral nutrients. After the moisture in the soil had been determined, samples were extracted by the neutral ammonium acetate method and the extracts were analyzed for the exchangeable ions: hydrogen, calcium, magnesium, and potassium.

From the analysis it has been observed that the base saturation of this soil was very low and conversely the hydrogen saturation was very high. In one surface sample the base saturation was as low as 5.2 percent. The amount of exchangeable potassium in the surface soils ranged from 100 to 200 pounds of potassium per acre for a 6-inch depth. This amount of potassium is usually considered adequate for good crop production but may become a limiting factor as the other elements are increased since the subsurface soils contain a much smaller amount of this element. The exchangeable calcium was exceptionally

low, especially in the subsoils, where only 28 pounds of calcium were found per acre for each 6-inch depth. The calcium level of the surface soils was higher but in no case exceeded 270 pounds per acre for a 6-inch depth.

The exchangeable magnesium ranged from an amount too small to be measured by the method employed to 43.2 pounds per 6-inch layer of an acre. It might be suspected that magnesium deficiency would occur on these trees under certain growing conditions, since these amounts of magnesium are considered inadequate for normal plant production.

Total and available phosphorus will be determined on the soils previously collected and on those obtained in the future, to see if the addition of organic matter has any mobilizing effect on phosphate. Mineral analyses will also be made of the samples collected in the future to determine the influence of mulch on the amount or mobilization of the various mineral nutrient elements.

The Fixation of Arsenic in Soils and the Influence of Arsenic Compounds on the Liberation of Fixed Phosphates. (Dale H. Sieling.) Anion fixation in soils is very important from the standpoint of the decrease in availability of phosphates added as fertilizers to the soil. This study was undertaken to see whether arsenates were fixed in a similar manner to phosphates and would replace fixed phosphates. If the arsenic from spray residues were fixed, it would show to some extent the reason why such quantities of arsenic do not depress the growth of plants in soils while growth of plants is inhibited in cultural solutions containing the same amount of arsenic. The fundamentals involved in anion exchange or fixation by the soil can best be studied by using pure clay fractions found naturally in soils.

Purified Kaolinite and Halloysite, clay minerals commonly found in soils, have been investigated for their property to adsorb arsenates. It has been found that these clay minerals, as they ordinarily exist in large deposits, do not fix appreciable quantities of either phosphates or arsenates at pH 3.0. Grinding of these minerals in a ball mill for a period of 20 days reduced the particle size to more nearly that of soil clay particles and increased the activity of both minerals in fixing arsenates and phosphates.

Five-gram samples of these minerals were shaken continuously for 24 to 72 hours in stoppered bottles containing measured quantities of a normal solution of either phosphoric or arsenic acid adjusted to pH 3.0 with sodium hydroxide. The fixation was measured by determining the decrease in concentration of the ion in the solution after removal of the clay by centrifuging. Fixation was not instantaneous but followed a pattern somewhat similar to that reported for phosphate by other workers and confirmed in these tests. Arsenate was fixed in quantities practically equivalent to phosphate by the Kaolinite clay but in somewhat smaller amounts than phosphate by the Halloysite; however both arsenate and phosphate fixation by pulverized Halloysite exceeded the amounts of these ions fixed by Kaolinite.

Further study is being conducted to establish the relative ability of each of these two negative ions to replace the other when it has been fixed by these clays.

CONTROL SERVICE

Philip H. Smith in Charge

The Fertilizer, Feed, and Seed Control Laws and the Dairy Law are all administered as one service. In addition, a large amount of work is done not only for other departments of the institution, but also for other State institutions and for citizens as well.

Fertilizer Inspection. Records for the year show that 118 firms have registered 501 brands of mixed fertilizers and fertilizing materials and 45 brands of agricultural lime and gypsum. The gross receipts from the registration of the fertilizer and lime products and from fertilizer tonnage fees were $14,711.41.

For inspection purposes 1,746 samples, representing 490 brands and 8,433 tons of materials, were drawn from stock found in the possession of 393 agents or owners located in 144 towns and cities of the State.

The following summary shows the character of these substances, as well as statistics with reference to their inspection.

	Brands Registered	Brands Collected	Samples Drawn
Mixed fertilizers	330	299	1,021
Ground bone, tankage and fish	35	35	190
Nitrogen products, mineral and organic	48	41	151
Phosphoric acid products	26	23	112
Potash products	24	23	85
Dried pulverized natural manures	23	22	73
Nitrate of potash	3	3	9
Peat products	3	2	2
Wood and cotton hull ashes	6	4	6
Emjeo (30% magnesium oxide)	1	—	—
Miscellaneous	2	1	5
Lime products	45	37	92
Totals	546	490	1,746

Feed Inspection. During the fiscal year 1,331 samples of feeding stuffs were officially collected and examined in the control laboratories. The gross receipts from the registration of feeding stuffs in 1941 were $27,220, derived from 1,361 brands at $20 each.

Dairy Law. During the year ending December 1, 1941, 6,738 pieces of Babcock glassware were tested; 107 certificates of proficiency were awarded; and 239 creameries, milk depots, and milk inspectors' laboratories were visited in order to check methods and to pass upon equipment in use. As a result of this inspection, four machines were condemned. These will be either replaced or put into condition to operate satisfactorily.

Miscellaneous Analytical Work. (Fertilizer and Feed Laboratory.) In addition to the work required by the several regulatory activities under its administration, Control Service is interested in collaborative work with other departments of the Experiment Station and College; the examination of samples of feeds, fertilizers, and other agricultural products submitted by citizens of the State; the testing of feeds and fertilizer bought by State institutions; and investigational work on new methods of chemical analysis for the Association of Official Agricultural Chemists.

In order to indicate the wide scope of the work, the following statistical data are appended:—

Fruit spray residue	16
Feeds, from farmers and dealers	57
Feeds, from State institutions	892
Feeds and forage crops, Experiment Station	182
Fertilizer mixtures	12
Ice Cream	130

Insecticides and fungicides	2
Limestone (AAA distribution)	12
Milk	362
Ore	8
Peat	1
Poultry feces (In connection with experiments)	9
Poultry grits	6
Referee and check samples, fertilizer and feed	11
Specimens for mineral poison	3
Superphosphate (AAA administration)	11
Water	4
Miscellaneous	19

Seed Control. From December 1, 1940, to December 1, 1941, the Seed Laboratory received and worked 3024 samples of seed, of which 942 were collected by the State Commissioner of Agriculture and 2082 were sent in by seedsmen, farmers, and various State institutions. In addition, 209 samples of flower seeds, for field tests only, were received from the State Commissioner of Agriculture.

Classification of these samples, with the total number of laboratory tests involved, is shown in the following summary. It will be noted that 3998 tests were required for the 3024 samples; 672 for purity, and 3326 for germination.

Number of Samples		Number of Tests Purity	Germination
544	Field Crops for Purity and Germination	544	544
2	Field Crops for Purity Only	2	—
235	Field Crops for Germination Only	—	235
81	Lawn and Other Types of Mixtures for Purity, Germinations involving 393 ingredients	81	393
35	Lawn Mixtures for Purity Only	35	—
7	Lawn Mixtures for Germination Only, Germinations involving 36 ingredients	—	36
1926	Vegetables for Germination Only	—	1926
46	Herbs for Germination Only	—	46
16	Flower Seeds for Germination Only	—	16
2	Flower Seeds for Purity Only	2	—
8	Flower Seeds for Purity and Germination	8	8
13	Tree Seeds for Germination Only	—	13
109	Tobacco Seeds for Germination Only	—	109
3024	Totals	672	3326

Field tests to determine trueness to type were conducted in cooperation with the Departments of Olericulture, Floriculture, and Agronomy, which tested 220 samples of vegetable seeds, 209 samples of flower seeds, and 30 samples of oats, respectively.

The Seed Laboratory cleaned 90 lots of tobacco seed for Connecticut Valley farmers. The gross weight of the tobacco seed was 131.28 pounds and the net weight for the cleaned seed was 102.17 pounds.

Corn, oats, barley, and wheat, (162 samples), purchased by various State institutions, were examined for conformity to grade purchased; and 98 samples of ground cattle and poultry feed, collected by inspectors or sent in by dealers and farmers, were examined microscopically.

THE CRANBERRY STATION
East Wareham, Massachusetts
H. J. Franklin in Charge

Injurious and Beneficial Insects Affecting the Cranberry. (H. J. Franklin.)

Hill Fireworm (*Tlascala finitella* (Walker)). One and a half acres of the Summit Cranberry Company's bog at Greene, R. I., replanted in the spring of 1941, were seriously infested in the hills by this insect in mid-July. Vines planted there in 1940 were also attacked but less severely and more along the runners lying on the sand than in the hills. These infestations were curbed completely by spraying and dusting heavily with rotenone materials.

About 50 acres of heavy vines of the Burrage bog at South Hanson, Mass., were found to be infested throughout by this insect from July 12 to August 12, 1941. The worms were everywhere rather plentiful there in the thicker clusters of vines during the latter half of July, being mostly in their tubes of frass and silk well down among the vines but considerably above the bog floor. They did considerable, but not severe, damage by devouring under leaves and blossoms. The superintendent of the bog said it had been similarly attacked by this pest in 1940.

Many of the worms were about full grown on July 19, 1941. A few were still present in their tubes among the vines of the Burrage bog on August 12. The largest were about thirteen sixteenths of an inch long, with the head black, the cervical shield black with a much-broken pale yellow stripe along its front margin, the body dark brown, striped lengthwise on the back and sides, except toward the hind end, with about eight narrow and broken pale yellow stripes, these being most conspicuous toward the front end. The first moths to appear in confinement emerged August 8 and more came out from August 10 to 20. Many live pupae remained on November 18.

Some of these worms were found in their tubes among the foliage of cultivated swamp blueberry bushes at the station.

Cranberry Root Grub (*Amphicoma vulpina*). Some of these grubs were sent to the Japanese and Asiatic beetle laboratory at Moorestown, New Jersey, in January 1941, to have their susceptibility to the milky disease organism determined. Mr. C. H. Hadley, in charge of the laboratory, reported later as follows:

> With further reference to my letter of January 10th regarding tests to determine the susceptibility of the cranberry root grub, *Amphicoma vulpina*, to the milky disease organism, we have completed the preliminary tests with the material which you sent me in January. Negative results were obtained both by injection tests and feeding tests with the type A milky disease organism, *Bacillus popilliae*. No evidence of milky disease development was observed either by macroscopic examination or upon microscopic examination of the blood of the injected individuals. Neither was there any indication of development of the organism in larvae which had been given opportunity to feed in infected soil. We must, therefore, conclude that this species of larva is not susceptible to milky disease infection.

Late in the spring, one of the cranberry growers started further tests of paradichlorobenzene as a control for this pest, applying the chemical with a fertilizer spreader at the rate of 1200 pounds an acre and covering it at once with about an inch of sand. His plots were examined late in August and nearly all the grubs were found to have been killed, even where flooding for frost protection and for insect control had been done soon after the treatment was applied. This treatment probably will be useful in special situations, as on bogs that cannot be treated with cyanide because they drain into public water supplies, or perhaps on bogs with a surface soil too dense to take in the cyanide solution readily.

Quite a number of bogs were reflowed from mid-May to mid-July, 1941, to check severe infestations of the root grub. This treatment was generally fairly successful, as it usually has been heretofore, but it was found that in several cases some grubs survived.

Cranberry Fruit Worm (*Mineola vaccinii*). Arsenate of lead, 8 pounds in 100 gallons of water with a casein spreader, applied at the rate of 400 gallons per acre at the times when derris and cryolite are most effective, controlled this insect very well on experimental plots, but less completely than derris or cryolite. Xanthone, both in a spray and in a dust, failed to affect it appreciably.

Gypsy Moth (*Porthetria dispar*). Cryolite, 14 pounds in 100 gallons of water, 400 gallons an acre, failed to cause much reduction in the number of maturing caterpillars on a bog, as did also dusting with 100 pounds of natural cryolite per acre.

Cranberry Girdler (*Crambus hortuellus*). Fifty pounds of 4 percent rotenone derris dust (without activator) to an acre killed nearly all the moths of this pest on a treated area, but was not quite so effective as pyrethrum.

Black-headed Fireworm (*Rhopobota*). An interesting development was the use of a mixture of cryolite and impregnated pyrethrum dust. Treatments with this mixture cost no more than those with clear pyrethrum dust and seemed to have greater value, especially with the first brood. The cryolite provides a considerable control after the pyrethrum ceases to act and so takes care of most of the young worms as the eggs continue to hatch.

Prevalence of Cranberry Pests. The relative general abundance of insect pests on Massachusetts bogs in the 1941 season was as follows:

1. Gypsy moth more abundant and destructive in Plymouth County than for many years, but much reduced on the middle and outer Cape, not giving much trouble there.
2. Blunt-nosed leafhopper (*Ophiola*) reduced as in recent years, because of general treatment.
3. Cranberry fruit worm only moderately troublesome and through working early; much less prevalent than in 1940, less eggs being laid by the moths, and the eggs being attacked by the *Trichogramma* parasite more severely and generally than usual.
4. Black-headed fireworm less abundant than usual and less than in 1940.
5. Firebeetle (*Cryptocephalus*) generally very scarce, but abundant on 10 acres of a bog in Norton.
6. Spanworms about the same as in 1940.
7. False armyworm (*Xylena*) even more prevalent than in 1940; more troublesome than for many years. Blossom worm even less prevalent than in 1940.
8. Cranberry girdler more harmful than in 1940.
9. Cranberry weevil about as in 1940.
10. Cranberry spittle insect (*Clastoptera*) and tipworm (*Dasyneura*) rather more troublesome than in 1940.
11. Spotted fireworms (*Cacoecia*) very few.

Control of Cranberry Bog Weeds. (Chester E. Cross.) Paradichlorobenzene, naphthalene, ferric sulfate, ferrous sulfate, copper sulfate, borax, kerosene, and a special petroleum oil, PD-428D, were tried on various kinds of bog weeds, 276 plots being treated. The results of many experiments have shown that many cranberry weeds can be killed in May and early June by treatments largely ineffective later in the season.

Paradichlorobenzene. It was observed in August 1940 that poison ivy (*Rhus Toxicodendron*) growing on areas of bog treated with 1200 pounds of this chemical to the acre and then resanded with half an inch of sand lost all its leaves, while cranberry vines on the same ground showed no injury. Cranberry bog plots with poison ivy were treated in September 1940, with amounts ranging from 800 to 5400 pounds per acre and then resanded with half an inch of sand. All these plots, except that which received 800 pounds per acre, showed a kill of three fourths of the ivy in the summer of 1941, with no injury to the cranberry vines or their crop. Paradichlorobenzene applied in June, July, and August, 1941, killed the ivy well, 1200 pounds per acre being as effective as greater amounts. A cover of three quarters of an inch of sand seemed necessary for the best results. Frost flooding two weeks after the chemical was applied did not seem to affect the kill of ivy.

Paradichlorobenzene, 1200 pounds per acre applied in June, July, and August and covered with three fourths of an inch of sand, killed 80 percent of considerable growths of chokeberry (*Aronia melanocarpa*), this weed losing all its leaves and its roots becoming brown and rotten in 12 days.

The following weeds endured paradichlorobenzene treatments as well as cranberry vines: Horse brier (*Smilax rotundifolia*), saw brier (*S. glauca*), small bramble (*Rubus hispidus*), coarse bramble (*R. villosus*), horsetail (*Equisetum*), asters (*A. spectabilis* and *A. multiflorus*), sphagnum moss, sensitive fern (*Onoclea sensibilis*), shield fern (*Thelypteris palustris*), bayberry (*Myrica caroliniensis*), sweet gale (*Myrica Gale*), wild bean (*Apios tuberosa*), red maple (*Acer rubrum*), hardhack (*Spirea tomentosa*), three-square grass (*Scirpus americanus*), spike rush (*Eleocharis tenuis*), and partridge pea (*Cassia chamaecrista*).

Naphthalene. Tests with naphthalene at 800, 1600, and 2400 pounds per acre were made in June, July, and August on poison ivy and other bog weeds. The chemical was broadcast by hand and covered with sand as in the paradichlorobenzene treatments. It failed to kill more than 10 percent of poison ivy even where it was applied in greatest quantity and had no effect on horsetail, hardhack, soft rush, reed canary grass, three-square grass, royal, sensitive, and shield ferns, or cranberry vines.

Ferric Sulfate. This year 32 plots with many kinds of cranberry bog weeds were treated with ferric sulfate at various rates. A carpet of young royal ferns on a peat-bottomed bog with poor drainage was killed with a broadcast treatment of 15 pounds per square rod, no cranberry vines or flower buds being hurt by it; 10 pounds per rod killed only 70 percent of the ferns and 20 pounds killed 8-10 percent of the cranberry branches.

One handful of ferric sulfate proved enough to kill 5-7 medium-sized cinnamon ferns. The vines around ferns treated with this amount under dry conditions showed no injury.

Ferric sulfate, 15 pounds per square rod, completely eliminated shield and sensitive ferns.

Single handfuls of ferric sulfate killed 2-4 clumps of soft rushes (*Juncus effusus*).

Spike rush (*Eleocharis*) was killed easily with 15 pounds of ferric sulfate or 35 pounds of ferrous sulfate to the square rod, but ferrous sulfate needs rain or a sprinkling of water to make it effective.

Ferric sulfate at 15-20 pounds per square rod must be used in late May or early June to be effective on rice cut-grass. This weed when 6 or more inches high, in July and August, tolerated a great deal of the chemical.

A little ferric sulfate at the base of each shoot was effective on wild bean. A handful was enough for at least 6 shoots.

Ferrous Sulfate. Dry ferrous sulfate, 40 pounds per square rod used early in June, killed 90 percent of long-leaved asters (*Aster spectabilis* and *A. Novi-Belgii*). The same treatment applied in July, when the asters were a foot high, killed only 25 percent.

Spike rush (*Eleocharis tenuis*) was controlled well with ferrous sulfate broadcasted at the rate of 40 pounds per square rod, June applications giving nearly complete kills while those made in July and August were less effective. Two competent growers reported the treatment as 95-100 percent effective when used in May.

Ferrous sulfate must be brushed off the cranberry vines when it is used in broadcast applications of 30 or more pounds per square rod.

Kerosene. Repeated experiments with kerosene showed the least injury to cranberry vines when it was applied before 10 a. m. or after 5 p. m. in June, July, and August. Mid-day applications, even with the air temperature below 80° F., injured cranberry tips and runners considerably. Recent tests of kerosene spraying in the early morning when the vines and weeds are wet with dew showed no injury to the cranberry vines, while the weeds seemed as sensitive to the kerosene as when sprayed under dry conditions.

Water white kerosene, 600 gallons per acre, gave 100 percent kill of loosestrife (*Lysimachia terrestris*) when applied before this weed was 5 inches high. The same kill was obtained later by mowing the taller loosestrife plants before spraying with kerosene.

Borax. Commercial borax, applied in July, 100 pounds per acre, killed Joe-Pye weed (*Eupatorium purpureum*) with little or no injury to cranberry vines. Heavier applications injured the vines.

Root Grub Flooding and Bog Weeds. Nine bogs flooded from mid-May to mid-July to kill grubs were examined in early September and late October to learn the effect of this flood on bog weeds. It had prevented no annual weeds from growing on the bogs but had shortened the season of several species so that they had failed to flower; others, like summer grass (*Panicum verrucosum*) and ragweed (*Ambrosia artemisiifolia*), had not attained normal growth but had flowered and seeded profusely; the trailing bramble (*Rubus hispidus*), rice cut-grass (*Leersia*), and wild bean (*Apios tuberosa*) had been reduced 90 percent; and the coarse bramble (*Rubus* sp.) and *Juncus* rushes had been killed entirely. Half the loosestrife (*Lysimachia*) and three fourths of the hair-cap moss (*Polytrichum*) had been killed where the water was over 18 inches deep, but these weeds had not been reduced much where the water was shallow. As many as 28 other species of perennial weeds grew more or less normally after the flooding.

COOPERATIVE CRANBERRY INVESTIGATIONS

Conducted by the Bureau of Plant Industry, United States Department of Agriculture, in cooperation with the Massachusetts Agricultural Experiment Station

H. F. Bergman, Senior Pathologist, Division of Fruit and Vegetable Crops and Diseases, in Charge

Development of Strains of Cranberry Resistant to False Blossom. (H. F. Bergman.) Nearly 1800 hybrid cranberry seedlings in pots were brought to East Wareham from Beltsville, Maryland, early in June 1941. This lot is part of the seedlings obtained from crosses made at East Wareham in 1938. They were set out temporarily on the State Bog and are to be transferred in 1942 to an area of new bog provided by the A. D. Makepeace Company of Wareham, Mass-

achusetts, under the terms of a memorandum of understanding drawn up with that company. Several other lots of seedlings from crosses made at East Wareham are set out in permanent locations on the State Bog where they will be allowed to grow until final assessment of their worth for propagation can be made.

Oxygen Content of Winter Flooding Water in Relation to Injury to Cranberry Vines. (H. F. Bergman.) Studies of the effects on cranberry vines of a lack of oxygen in the water during the winter flooding period were continued, in an attempt to correlate various types of injury with known low contents of dissolved oxygen over approximately known periods and to obtain additional data as to the conditions under which injury occurs. Three cylindrical sheet-iron tanks, about 5 feet in diameter, were placed on the State Bog, one each on sections planted with vines of Early Black, Howes, and McFarlin varieties. The bog was flooded on December 5, 1940, and froze over within a few days and remained frozen continuously until about the middle of March. Covers to exclude light and thereby prevent the liberation of oxygen by photosynthesis were placed on the tanks on January 18, 1941.

The importance of photosynthesis in maintaining the dissolved-oxygen content of the water on a winter-flooded bog covered with ice is shown by the course of this oxygen content outside and inside the tanks during the winter. The amount of dissolved oxygen in the water outside the tanks on Howes, Early Black, and McFarlin vines increased from 5.3, 6.4, and 6.8 cc. per liter, respectively, on January 15 to 7.2, 7.9, and 8.3 cc. per liter, respectively, on January 24 as a result of photosynthesis in the cranberry vines. A heavy snowfall on January 24 prevented photosynthesis by excluding light, while the consumption of oxygen by respiration of the cranberry vines and of organisms which decompose organic matter continued. As a result the dissolved oxygen in the water outside the tanks decreased to less than 2 cc. per liter, although probably for not more than 5 or 6 days. A heavy rain on February 7 removed most of the snow and the remainder froze into the ice. Thereafter, the dissolved oxygen in the water outside the tanks on Early Black and McFarlin vines increased rapidly, and by February 12 it had come up nearly to the same content as on January 24. The oxygen content of the water outside the tank on Howes vines remained near 2 cc. per liter until February 20 when it also began to increase.

The dissolved oxygen in the water inside the tanks on January 15 varied from 4 to 5 cc. per liter. Because of the exclusion of light by the covers, little or no photosynthesis could take place and the oxygen content of the water decreased steadily. By January 24 and from then until February 27 there was no dissolved oxygen in the water inside the tank enclosing vines of the Howes variety, and not more than 0.4 cc. per liter from February 27 until March 20. In tanks enclosing the other two varieties of vines there was less than 1 cc. of oxygen per liter of water for about a month from February 1 to March 1 except in the tank on Early Black vines where the oxygen content of the water increased to slightly more than 2 cc. per liter for a few days around February 12. On February 28 nine inches more water was pumped onto the bog which brought the oxygen content of the water up to more than 2 cc. per liter. Thereafter, except for a few days about March 13, there was never less than this amount of oxygen in the water. Soon after March 20 the ice went off the bog and the dissolved-oxygen content again increased.

The water was taken off the bog on April 1, 1941, and the tanks were then removed. Counts were made during the summer and autumn to ascertain the average number of flowers and fruits per upright, the percentage of buds killed, and the percentage of flowers that set fruit on vines of each of the three varieties both inside and outside the tanks where the dissolved oxygen content of the water

during the winter flooding period was known. The yield of berries of each variety inside the tanks and on measured areas outside was determined.

The effect of an insufficient supply or of complete deprivation of oxygen over a period of a month or more during the winter flooding period is shown clearly by the reduction in yield of berries from vines inside the tanks in comparison with vines outside. Furthermore, the yield outside but near the tanks was very much less than that from vines on slightly higher ground and therefore less deeply flooded. The yields, in barrels per acre, were as follows: Early Black, inside tank 28, outside near tank 34, on slightly higher ground 75; Howes, in the corresponding locations, 50, 72, and 110; and McFarlin, inside tank 39, outside on higher ground 81.

Although the dissolved-oxygen content of the water on the less deeply flooded areas during the winter was not determined, it has been found repeatedly that the oxygen content of water is less in deep places than in shallow, even a few inches making a significant difference, particularly when there is ice over the bog. It is probable, therefore, that the oxygen content of the water in the less deeply flooded "high" places did not fall below 2 cc. per liter for more than one or two days during the winter, if at all. This indicates that if the dissolved-oxygen content of the water is less than 2 cc. per liter for even a few days the yield is greatly reduced. A longer period of oxygen deprivation caused a further reduction in yield, but even within a variety the reduction was not proportional to the length of time during which the oxygen deficiency existed. Prolonged oxygen deficiency affected vines of different varieties differently. There was no oxygen in the water inside the tank on Howes vines for nearly two months; yet these vines yielded better than Early Black vines inside a tank in which the oxygen in the water was less than 1 cc. per liter for not more than a month and approached exhaustion for about two weeks only. This probably is because the Early Black vines had been badly injured by a lack of oxygen in the water during the flooding period of the winter of 1939–40 and therefore were more susceptible to injury.

The first effect of an oxygen deficiency during the winter flooding period is to reduce the number of flowers that set fruit. Injury of this kind apparently may occur if there is less than 2 cc. of dissolved oxygen per liter in the water for as short a time as 3 or 4 days. In all three varieties the percentage of flowers setting fruit was lowest on vines inside the tanks, where the oxygen deficiency was greatest, and was lower on vines in slightly deeper water than on those most shallowly flooded, although in some cases the difference was small.

A greater deficiency of oxygen or a deficiency over a longer time causes the death of flower buds and then of the uprights on which the flowers are borne. The percentage of dead buds on vines of all three varieties in the areas outside but near the tanks was considerably greater than it was on vines on slightly higher ground. In the Early Black and Howes varieties the percentage of dead buds on vines inside the tanks was slightly less than on those outside, whereas it should have been greater. One reason for this discrepancy may be that more of the flower buds on vines inside the tanks than on those outside were killed at such an early stage of development that they were not detected when the counts were made. This is indicated by the lower average number of flowers per upright for these varieties on vines inside than on those outside the tanks. Another reason is that in making the counts only flowering uprights were taken; no attention was paid to sterile ones, a considerable proportion of which probably were flowering uprights on which the buds had been killed at a very early stage of development. For the same reasons the values for the percentage of flowers setting fruit on vines of the Early Black and Howes varieties inside the tanks are higher than they would otherwise have been.

The average size of berries from vines inside the tanks was smaller than that of

berries from vines just outside the tanks or from vines on slightly higher ground. Berries of the Early Black variety showed the greatest difference. Those from vines inside the tank averaged 158 to the cup (½ pt.); from vines just outside, 118 (average of 93 counts); and from vines on slightly higher ground, 110 (20 counts). The average number of berries per cup for the other two varieties was as follows: Howes, inside tank 115, outside near tank 105, outside on slightly higher ground 100; McFarlins, inside tank 94, outside near tank 94, on slightly higher ground 84. Many berries failed to grow to a size large enough to be picked. The proportion of these berries was greater from vines inside the tanks or from vines outside near the tanks than from vines on higher ground.

The reduction in the size of picked fruits and the failure of berries to grow to a size large enough to be picked probably is due to an inadequate food supply during the summer because of injury to the leaves of the preceding season which reduced their capacity to synthesize carbohydrates. Vines of all three varieties inside the tanks lost more of their old leaves than did vines outside. This was true especially of Early Black which lost nearly all the old leaves from vines inside the tank. Even when old leaves remained on the vines, many of them were injured and probably their effectiveness in the formation of carbohydrates was greatly reduced.

The following conclusions are drawn: Injury to cranberry vines occurs when the dissolved-oxygen content of the water falls below 2 cc. per liter. This happens apparently only when the ice on a winter-flooded bog is covered with snow, which excludes light and thereby prevents photosynthesis and the resultant liberation of oxygen which ordinarily keeps the oxygen content of the water high enough to prevent injury. The injurious effect on cranberry vines of a lack of oxygen for several days to a few weeks is shown ultimately in the reduction of the crop. Reduced yields are the direct result of (1) reduction in the number of flowers setting fruit, (2) death of flower buds and flowering uprights, and (3) reduction in the size of fruits, both those harvested and those too small to pick.

DEPARTMENT OF DAIRY INDUSTRY

J. H. Frandsen in Charge

Studies on Chocolate-Flavored Milk. (W. S. Mueller.) The study of chocolate-flavored milk, with especial emphasis on its nutritive value, continues to be a major project in this department. For a long time it had been assumed that the well-known nutritive properties of plain milk were also present in chocolate-flavored milk. In 1937 it was discovered that milk containing 2.5 percent or more of cocoa was not equal in nutritive value to plain milk, when fed to white rats. Since then experiments have been in progress to learn more about the various constituents of cocoa and their possible effects upon the nutritive value of the milk. In addition to the nutritional studies, investigations on improving the method for processing chocolate milk are in progress.

1. *The Effect of Cocoa Upon Digestibility of Milk Proteins.* (L. D. Lipman and W. S. Mueller.) The addition of cocoa to whole milk powder in quantity equivalent to approximately 3.6 percent by weight on a fluid milk basis reduced the digestibility of the milk protein 7.8 percent. The kind of cocoa, Dutch or American-process, and the inclusion of 7.1 percent of cocoa fat in the ration, did not significantly affect the percentage reduction. Proteins of the Dutch and American-process cocoa were found to be 38.1 and 44.5 percent digestible, respectively. The results of this study were published in the *Journal of Dairy Science* 24, May 1941.

2. *The Significance of Tannic Substances and Theobromine in Chocolate Milk.* (W. S. Mueller.) The relative toxicity of pure theobromine, pure tannic acid, and two cocoa powders varying in content of tannic substances was determined by feeding these substances in a basal diet to white rats. Theobromine was non-toxic to albino rats when the ration contained 0.27 percent of this alkaloid, and tannic acid was toxic when the ration contained 2 percent of this substance. These amounts of tannic acid and theobromine in the diets were equal to those in a chocolate milk made with 3.6 percent cocoa powder which contained 12.15 percent tannic substances and 1.7 percent theobromine. A cocoa powder containing 12.15 percent of tannic substances was more toxic than a cocoa powder containing only 2.67 percent of tannic substances, but was less toxic than pure crystalline tannic acid. A concentrated extract of cocoa was non-toxic to rats when fed at the rate of 8 percent of the ration. The hemoglobin levels of the blood of rats fed theobromine, crystaline tannic acid, and cocoa powder containing varying amounts of tannic substances did not vary from the normal enough to be of any significance. Results from this study indicate that the toxicity from cocoa can be greatly reduced by selecting a cocoa or chocolate which is low in tannic substances, or preferably by using an extract of cocoa as the flavoring material when feasible.

3. *The Availability of the Iron of Cocoa and of Additional Iron when Associated with Cocoa.* (F. Kinder, H. S. Mitchell, and W. S. Mueller.) This study is reported by the Department of Home Economics Nutrition.

4. *Effect of Adding Cocoa to Cow's Milk on the Utilization of Calcium and Phosphorus.* (M. R. Cooney and W. S. Mueller.) This study is reported by the Department of Home Economics Nutrition.

5. *The Bacteriology of Chocolate Milk, Chocolate Syrup, and Cocoa Powders* (R. W. Swanson, J. E. Fuller, and W. S. Mueller.) This study is reported by the Department of Bacteriology.

6. *Effect of Cocoa on the Vitamin C Content of Milk.* (W. S. Mueller.) Vitamin C is present in fresh raw milk to the extent of 12 to 20 mg. per quart. If this could all be retained, milk would be a significant source of vitamin C, since the higher figure is about half the daily requirements of an adult. Therefore, the handling of milk from the time it is drawn until it is consumed, in a manner which will conserve the vitamin C, is an important problem today.

If chocolate milk is substituted for plain milk, it is important to know what effect the cocoa has upon the retention of vitamin C. Preliminary studies on the relative retention of vitamin C in plain milk and chocolate milk have been made, using the 2, 6-dichloro-phenol-indophenol in both visual and electrometric titrations. Results of these studies indicate that the addition of cocoa to milk hastens the destruction of vitamin C. When both milks were stored, under identical conditions, the plain milk lost 22 percent of the original vitamin C, while the loss for chocolate milk was 77 percent. This difference in loss of vitamin C is typical of the results obtained. Studies are also being made to determine which method is most suitable for measuring the vitamin C content of chocolate milk.

7. *Effect of Cocoa on the Coagulation of Milk.* (W. S. Mueller.) It has been reported by a foreign investigator that cacao bean contains an enzyme with rennet effect. Dry, it withstands heating to 248°-284° F. and may, therefore, be found in cocoa powder. The optimum temperature of the enzyme is 149° F. and the optimum pH is below 6.3. By heating a suspension of cocoa powder in water (176° F.), the enzyme will be destroyed.

Since the knowledge of this enzyme may be of practical interest to the consumer as well as to the manufacturer of cocoa, a study was undertaken to deter-

mine whether cocoa powders commonly sold in this country contain such an enzyme. In preliminary studies 25 samples of cocoa powder have been investigated. When one percent of cocoa powder, by weight, was added to good quality milk (.16 percent acidity), only one cocoa powder coagulated the milk shortly after heating at 149° F. for 30 minutes. Further investigation will be made, using milk of higher acidity and of a low protein stability, and also adding a larger amount of cocoa to the milk.

8. *The Effect of Various Methods of Pasteurization on Chocolate Milk.* (W. S. Mueller and A. M. Shipley.) Further experiments in pasteurizing chocolate-flavored milk by the Electropure process substantiate in a general way the results of last year. However, in the latest trials, the Electropure method was more efficient in the reduction of the bacteria count of highly viscous chocolate milks.

Cooperative Study with the American Dairy Science Association Committee on Methods for Determining the Curd Tension of Milk. (W. S. Mueller.) The final report of the committee on methods of determining the curd tension of milk was published in the *Journal of Dairy Science*, 24, September 1941.

Improving the Flavor and Keeping Properties of Milk and Some of its Products. (W. S. Mueller and M. J. Mack.) A major flavor defect of orange or lemon ice and sherbet is the development of terpene odors and flavors, as a result of the oxidation of the oil in the flavoring material. It seems logical that this flavor defect could be prevented or minimized by the addition of an antioxidant. Therefore, the antioxygenic effect of oat flour and of a concentrated extract of oat flour was studied by adding 0.5 and 0.1 percent of these substances, respectively, to lemon and orange ices. Fresh orange and lemon juice were used as the flavoring materials. The control samples developed a harsh flavor after four days, while the samples containing the antioxidants had a typical orange and lemon flavor for several weeks. In the concentrations used, the concentrated extract of oat flour was slightly more effective than the powdered oat flour. A protective action was also noted when a sugar which had been treated with the oat flour concentrate was added to the orange and lemon ices.

Cocoa flour was found to be an effective antioxidant when added directly to milk. Also cocoa flour and oat flour possessed antioxygenic properties when used for treating paper milk-container stock.

Factors which may affect the solubility of the antioxidant oat flour in ice cream mix and milk are being investigated. The effect of temperature of the milk at the time the oat flour is added has been studied. No significant differences were noted for temperatures ranging from 50° to 160° F.

The Use of Corn Syrup Solids in Ice Cream and Ices. (M. J. Mack and J. H. Nair.) The use of dried corn syrup as a sweetener in frozen dairy products was discussed in a previous publication. (Corn Syrup Solids Improve Frozen Dairy Products. Lynn R. Glazier and Merrill J. Mack. *Food Industries*, June 1941, p. 68.) The replacement of 20 to 25 percent of the sucrose ordinarily used in ice cream by corn syrup solids was found to affect but slightly the sweetness of the product and to improve somewhat the body and texture and melting characteristics of the ice cream. Consumer acceptance of ice cream containing sucrose and corn syrup solids seemed to be slightly greater than of that containing sucrose as the only sweetening agent. During the first part of the study it became evident that factors other than the sugar content of ice cream may affect the apparent sweetness of the product. Therefore, the project is being continued to study some of these factors.

Preliminary results indicate that the apparent sweetness of ice cream may be affected by such factors as the source of butterfat, the ratio of fat to serum solids,

the mineral salts present, and the melting characteristics of the product. Other factors are also involved, such as the serving temperature, the type of flavoring used, and the ratio of solids to sugar in the ice cream.

A Study of New Stabilizing Materials for Ice Cream. (M. J. Mack and A. M. Shipley.) Several new stabilizers have recently been developed and already are used to some extent in ice cream. The stabilizer employed affects a number of properties, such as the viscosity, titratable acidity, and whipping ability of the mix, and the flavor, body and texture, and melting properties of the ice cream. The object of this investigation is to compare the effectiveness of the new stabilizers with those already known to be desirable in ice cream.

Among six stabilizers thus far observed, two were as effective as gelatin or sodium alginate in producing mix viscosity and firmness of body in ice cream. They allowed satisfactory whipping of the mix and permitted normal melting of the product. The chief difficulty thus far encountered is that some of the newer stabilizers are somewhat lacking in solubility. The work will continue with a study of the effects of each active material employed, with the object of finding a combination of stabilizing materials more satisfactory than those now available.

The Appearance of Melted Ice Cream. (M. J. Mack.) The melting characteristics of ice cream have recently received more consideration, as is evidenced by the fact that the new score card approved for ice cream by the American Dairy Science Association allots 5 points to this item. Severe defects in melting appearance usually are due to loss of stability of the casein in the ice cream, while minor defects may be due to other causes.

Slight increases in the acidity of mixes cause ice cream to appear curdy or "whey off" when melting, if normal homogenization pressures are maintained. Standardization of the acidity by the addition of some suitable alkaline material does not injure the melting appearance in ice cream of average composition unless the original acidity is greater than approximately 0.24 percent. The melting characteristics are affected to a lesser degree by such factors as the components used, the percentage composition, the methods of freezing, and so on.

A Comparison of the Electric and Vat Methods of Pasteurization. (L. D. Lipman, J. H. Frandsen, and H. G. Lindquist.) Split batches of raw milk were pasteurized in an electric pasteurizer at 162° for 16 seconds, and in a spray vat at 143° for 30 minutes. The following conclusions may be drawn.

1. The reduction in vitamin C content of milk was less rapid in the electric-pasteurized milk than in raw or vat-pasteurized milks.
2. The electric method gave better, that is less, phosphatase units than the vat method.
3. Vat-pasteurization decreased the cream volume, while the electric method gave the same cream line as that of the raw milk. However, the difference between the two methods of pasteurization was so small that no definite conclusions should be drawn as to which of the two methods results in the smaller decrease in cream volume.
4. There was no significant difference in the efficiency of bacterial reduction between the vat and electric methods of pasteurization. With some milks the electric method seemed to show the higher percentage kill, whereas with other milks the vat method seemed to show the higher percentage kill. A probable explanation for this is that the types of bacteria or bacterial flora present in the milk will affect the percentage killed by pasteurization. For example, evidence seems to show that thermophilic bacteria are killed by the high-temperature-short-time pasteurization but survive and may grow at vat-pasteurization temperatures. The reverse seems to be true with the thermoduric types of bacteria.

5. Electric-pasteurized milk became oxidized less rapidly, less frequently, and to a lesser degree than did vat-pasteurized milk. A cooked flavor was found more often and more pronounced in vat-pasteurized milk than in electric-pasteurized milk.

6. Generally it can be said that electric pasteurization (high temperature-short time) of milk will tend to prevent development of oxidized and cooked flavors, and such milk will have a higher flavor score than vat-pasteurized milk at the end of 48 hours.

A Study of the Efficiency of the McCormick-Deering Cream Separator (Standardizer.) (A. M. Shipley and J. H. Frandsen.) In 1938 a report was given of a study of the suitability and practicability of the DeLaval Multipurpose Separator. In some further work on this project, tests have been made on the McCormick-Deering Cream Separator. The following results were obtained:

	Before	After
Sediment	9.8	9.8
Flavor Score	22.5	23.25
Fat (percent)	3.0	4.0
Skim (percent)	—	.01
Total solids (percent)	11.395	12.35
Bacteria per c. c.	1500	2400
Curd tension	60	57.5
Creaming (pint bottle)	2 inches	2½ inches

Standardization, in addition to providing a milk of desired fat content, seems also to give milk of slightly better flavor. Standardization with a mechanical standardizer is, in our judgment, more practical and economical than standardization by siphoning or foremilking.

Some Factors Affecting the Wheying Off of Cultured Buttermilk. (L. R. Glazier and H. G. Lindquist.) When cultured buttermilk is allowed to stand in storage, it frequently separates into a layer of curd and whey. In this study it was found that the higher the developed acidity, the less curd separation and wheying off occurred. Pasteurization at a temperature of 200° F. was more desirable for the milk to be used for culturing than was pasteurization at 180° F., and temperatures below 180° F. should be avoided. Storage temperatures as high as 50° F. should be avoided. Storage at 33° F. gave the best results of any of the temperatures used, in preventing wheying off of buttermilk in storage. The longer the buttermilk is held, the more separation and wheying off there is likely to be. Therefore, smaller batches should be made in order to eliminate long storage periods. (Published in *Milk Plant Monthly*, 30 (5): 27-30, 1941.)

DEPARTMENT OF ECONOMICS

Alexander E. Cance in Charge

Land-Use Problems in Massachusetts in Relation to a Balanced Program of Land Utilization. (David Rozman.) The major phase of this project has been completed and the results presented for publication as Experiment Station Bulletin 387. This study deals with the interrelationship of major uses of land on a State and local basis. To an analysis of the historical trend in agricultural and forest land uses is added consideration of other important land uses such as recreational, part-time farming, residential, and industrial. The summary and main conclusions are as follows:

1. The classification of land on the basis of soil and topography indicates that 50.2 percent of the total area of the State is suitable for agricultural utilization.

2. The percentage of agricultural suitability varies from 31 percent in Barnstable County to 62.7 percent in Worcester County.

3. In 1880, before the decline in agricultural land use set in, 41.4 percent of the State area was represented by improved farm land. In 1940 this proportion had declined to 15.4 percent.

4. The major local land-use factors responsible for the decline of improved farm land relate in varying degrees to changing types and systems of farming; soil erosion and deterioration; non-resident land ownership; the disappearance of town industries; and the growth of residential, recreational, commercial, and other more intensive uses of land.

5. Non-resident ownership of about one-third of all land in rural towns has contributed to the increasing amount of land under wooded cover.

6. Of the total State area, 64.3 percent is under wooded cover. The highest proportion is in Barnstable and Berkshire counties, 73.1 and 71.8 percent, respectively; the lowest in Essex and Middlesex counties, 52.0 and 57.8 percent, respectively.

7. In the towns below 10,000 population there are 89 with no existing local industries. In each of 87 of the remaining 184 towns, local industries provide employment for less than 100 persons.

8. The demand for more intensive uses of land has affected farming through higher land values and taxes.

9. The average value per acre of farm land and buildings is $37.38 in the lowest third of the towns below 10,000 population. In the highest third the average value is $284.57 per acre.

10. From the standpoint of land-use pattern and land-use adjustments needed, five types of rural towns are indicated in Massachusetts:

A. Towns characterized by predominantly poor land, declining population, limited amount of agricultural land utilization, and extensive areas under wooded cover.
   Major adjustments needed: Extension of public ownership of forest land, elimination of isolated settlement, development of recreational facilities, possible discontinuation of the town as an independent political unit.

B. Towns with a fair agricultural background, experiencing recent dislocation in local industries.
   Major adjustments needed: Realignment of town expenditures, fuller utilization of land resources for agriculture and other uses, rehabilitation of industrial opportunities.

C. Towns with favorable physical background for well-rounded agricultural land utilization.
   Major adjustments needed: Conservation of soil, better adaptation of crops, and better care of woodlots.

D. Towns with receding agricultural land utilization as a result of expansion in more intensive uses of land.
   Major adjustments needed: Prevention of increase of idle land held for speculative purposes, primarily by more equitable taxation of land used in agriculture.

E. Towns with a balanced system of agricultural and other land uses.
   Major adjustments needed: Maintenance and improvement of local conditions through farsighted policies of local people and their planning agencies.

Problems of Rural Youth in Massachusetts. (David Rozman, Gilbert Meldrum, Ruth E. Sherburne.) This study was undertaken during the past year in cooperation with the United States Department of Agriculture to determine and analyze the most important problems of rural youth in Massachusetts. Nearly 600 schedules were obtained in selected towns in four counties, including young people, both in school and out of school, ranging in age from 16 to 25. For 40 percent of the boys the main problem had to do with finding a job, making a living, or getting started in farming. For one-fourth of the girls the major problems were also economic. Of the problems mentioned by both boys and girls, 25 percent concerned education and vocational guidance.

The results of this study have been analyzed and presented as Experiment Station Bulletin 386.

DEPARTMENT OF ENGINEERING

C. I. Gunness in Charge

Cranberry Storage Investigation. (C. I. Gunness, H. J. Franklin, and C. R. Fellers.) The storage of Early Black cranberries in a modified atmosphere was continued during the 1941 season. All the berries were picked and stored on September 8 and removed from storage and screened on November 14. Three lots of berries were stored at 35 degrees and three lots at 45 degrees. One lot at each temperature was kept in normal atmosphere, one lot in an atmosphere containing 5 percent carbon dioxide and 2 percent oxygen, and one lot in an atmosphere containing 10 percent carbon dioxide and 10 percent oxygen. The berries stored in modified atmospheres were kept in sealed sheet iron cabinets having a capacity of 2 barrels each. Means were provided for removal of excess carbon dioxide by circulating the air from the cabinets through a solution of sodium-hydroxide. Excess moisture was removed from the cabinets by circulating the air through calcium chloride.

Apparently this process was ineffective as the berries were covered with moisture when the cabinets were opened at the end of the test.

Berries stored in normal air at 35 degrees and 45 degrees showed the usual differences in storage loss which have been observed in former years. Those stored at 35 degrees showed a storage loss of 4.7 percent, while those at 45 degrees showed a loss of 11.6 percent. All the berries stored in the modified atmospheres showed greater losses than those stored in normal air. It is not known, however, whether this increased loss was due to the composition of the atmosphere or to the excessive moisture in the cabinets. The experiment will have to be repeated next year with more efficient equipment for removing excess moisture from the cabinets.

Berries stored in normal air developed very much better color at 45 degrees than at 35 degrees. Berries stored in modified atmospheres on the other hand, developed no better color at 45 degrees than at 35 degrees; and berries stored in modified atmospheres at 35 degrees were not as well colored as those kept in normal air at 35 degrees.

Apple Storage Investigation. (C. I. Gunness in cooperation with Department of Pomology.) A small room for the storage of apples in a modified atmosphere was prepared during the summer of 1940 and filled with McIntosh apples that fall. The room had a small leak and it was not possible to reduce the oxygen content to the desired 2 percent. Considerable variation in temperature increased air circulation through the leak, and it was not possible to reduce the

oxygen below 11 percent. The results obtained with the storage were, therefore, unsatisfactory, the fruit on removal being in about the same condition as fruit kept at 32 degrees in a normal atmosphere.

During the past summer the leak was stopped and a new cooling unit installed with a sensitive thermostat. The room is now operating with an atmosphere of 5 percent carbon dioxide and 2 percent oxygen. Results will not be available until the room is opened in the spring.

Frost Protection on Cranberry Bogs. (C. I. Gunness.) The wind machine used for frost protection was moved to a dry bog in the spring of 1941. It was operated both in the spring and in the fall. The results were in general unsatisfactory in that protection was given over too small an area.

Poultry House Investigation. (C. I. Gunness and W. C. Sanctuary.) The investigation on the operation of electric brooders in colony houses was continued during 1941. The purpose of the investigation was to see whether litter could be kept dry in a brooder house through the use of soil heating cable. Very wet sawdust litter was placed in the houses and while the litter in the house equipped with soil cable was drier than in the others, it was not sufficiently dry to be considered satisfactory. It was felt, however, that the litter was too wet at the start to make a fair test of the effect of the soil cable. Good chicks were reared in spite of the damp litter conditions. The test is being repeated this year.

Ceiling temperatures were taken during the winter months of 1941 in insulated and non-insulated pens through the use of thermocouples. Ventilation was adjusted so as to keep the same temperature in insulated and uninsulated pens. It was found that on cold nights the ceiling temperatures in insulated pens would run one degree lower than air temperatures within the pen, while in uninsulated pens the ceiling temperature would run 4.5 degrees lower than the air temperature. This would indicate that insulated pens are more comfortable for the birds even though there may be but slight difference in air temperatures.

Observations taken during the late summer showed ceiling temperatures from 5 to 13 degrees higher in uninsulated pens than in insulated pens with equal air temperatures. In sections where the black composition roof had been painted with aluminum paint, the ceiling temperature in uninsulated pens was reduced from 85 degrees to 82 degrees on the rear slope when compared with sections which had not been painted. In insulated pens the aluminum paint produced a difference of 3 degrees in ceiling temperatures on the rear slope. On the front slope the black surface gave a ceiling temperature of 101 degrees in the uninsulated pens with a temperature of 92 under the aluminum paint. In the insulated pen the black gave 88 degrees and the aluminum 85 degrees on the front slope.

DEPARTMENT OF ENTOMOLOGY

Charles P. Alexander in Charge

Investigation of Materials which Promise Value in Insect Control.

Oil sprays for dormant applications. (A. I. Bourne and W. D. Whitcomb.) The early season of 1941 was unusual in many respects. March was characterized by cold, windy weather with the average temperature below normal and snowfall above the average. April, however, was marked by abnormally high temperature which persisted throughout the month and culminated in the peak of 90 degrees reached on the 20th. The transition from winter to spring was very

abrupt, and since it was not accompanied with the usual amount of rainfall the snow and frost disappeared rapidly and the soil dried quickly, furnishing excellent ground conditions for early spring spraying. Plant and animal life responded to the unusually warm weather. Seasonal development began early and progressed rapidly. In most orchards the period for delayed dormant application of oil sprays was very brief so that many growers were unable to complete this application before bud development progressed to the pre-pink stage. In the college orchards the delayed dormant period was passed in 4 to 5 days, and some blocks received the pre-pink spray 3 days after the delayed dormant. In the experimental blocks the trees had received the dormant, delayed dormant, pre-pink, and pink sprays by April 28 in contrast to 1940 when in the same blocks the delayed dormant spray was applied April 29. Very few instances of damage to fruit buds or foliage by oil sprays were observed or reported in spite of the unseasonable temperature. This was probably due in large measure to the relatively small amount of oil spraying done.

In the cooperative project with the Dow Chemical Company on the investigation of DN sprays, attention was focused on the relative tolerance of various types of ornamentals (coniferous and deciduous) to dormant applications of DN–oil sprays. In these tests different concentrations of dinitro-ortho-cyclo-hexylphenol (DNOCHP) compounds were used. None of the common deciduous ornamentals showed any ill effects from the application aside from a slight retardation in some cases. Moderate burning was noted on Irish juniper and more serious injury resulted on rhododendron and laurel.

In strictly dormant application on apples for the control of overwintering eggs of European red mite, 2 dry-mix DN compositions containing 40 percent DNOCHP and DNOC (dinitro-orthocresol) respectively were combined with 2 standard types of commercial oil sprays. Application of a DNOCHP–oil solution of 7.9 pH caused no injury to fruit or leaf buds nor retardation in development. A DNOCHP–oil solution of 6.6 pH caused noticeable retardation in development but no actual killing of buds. The DNOC–oil solutions of 5.8 pH and 4.8 pH both caused marked retardation of bud development. The combinations containing the DN compounds were somewhat less effective against red mite eggs than were the oils alone.

Counts of young mites on the test trees showed 1,660 mites per 100 spurs following DNOCHP–oil emulsion; 675 following DNOC–oil emulsion; and 465 following the oil emulsion alone. Check trees showed 13,055 mites per 100 spurs. Following DNOCHP+miscible oil, counts showed 20 mites, DNOC+miscible oil, 80 mites; and miscible oil alone, 15 mites per 100 spurs.

In applications at Waltham on April 8, 1941, no noticeable injury resulted to bark or twigs from DN–oil mixtures having a pH value of 8.0, 7.45, or 6.75. All of the mixtures retarded bud development slightly, and when trees were in full bloom there was slightly more retardation on McIntosh and Wealthy from the alkaline mixture than from the more acid mixture. It was also observed that a dinitro-orthocresol–oil mixture retarded bud development slightly less than dinitro-ortho-cyclo-hexylphenol in combination with either alkaline or acid oil emulsion.

All of the sprays gave good control of the European red mite eggs and reduced the average number of living mites per spur on April 30 by 90 percent or more. No significant differences between the materials resulted, but the dinitro-ortho-cresol–oil mixture, which is generally considered safer than the DNOCHP mixture, gave very satisfactory control of the red mite.

At the college, incidental records on the overwintering eggs of aphids, including heavy infestations on birch and pine and moderate infestations on several ornamentals, showed practically perfect kill following the use of DN compounds.

The contrast between sprayed and unsprayed specimens of Viburnum was conspicuous. (See page 54.) The foliage of unsprayed checks was tightly curled and distorted and the the plants were of little use as ornamentals, while on the sprayed plants freedom from aphid attack allowed full and perfect foliage, a condition that is rarely seen in this region.

Dormant application of a commercial oil emulsion at 5 percent dilution combined with dry-mix DNOCHP gave excellent control of oystershell scale on lilac and willow. Light to moderate infestations were eliminated. On heavy infestations with thick encrustation of the bark, some slight hatching took place but from a commercial standpoint it was negligible.

Summer Treatments for the Control of European Red Mite. (A. I. Bourne and W. D. Whitcomb.) Another abnormal feature of a very unusual season was the comparative scarcity of European red mite in most orchards in midsummer and late summer. The infestation was negligible in the college orchard. A heavy outbreak in a Berkshire County orchard offered opportunity for checking the efficiency of a DN dust (a 1.7 dicyclohexylamine salt of DNOCHP). The red mite population before dusting amounted to 54.8 mites per leaf. Counts 24 hours after treatment showed an average of 9.6 mites per leaf, and similar counts made 8 to 9 days after treatment showed an average of one mite per leaf—an 82.5 percent reduction in 24 hours and a 98.1 percent reduction after an 8- to 9-day period.

Tolerance tests of this dust and of a DN spray containing 20 percent of the toxicant designed for summer use, on 28 different types of fruit and shade trees, ornamentals, and garden plants subject to mite attack showed no injury following either the dust or the spray.

In August, tests of new materials for the control of the European red mite on apple were made both at a commercial orchard in Gleasondale and at the Waltham Field Station. The most effective material was a dicyclohexylamine salt of dinitro-ortho-cyclo-hexylphenol mixture containing 20 percent of the toxicant together with dispersing and wetting agent. In four tests of this material at the rate of 20, 24, and 30 ounces in 100 gallons of spray, the average reduction of living red mites was 94.2 percent. There was no significant difference between the dosages used, indicating that the smallest amount (20 ounces in 100 gallons) was adequate. A 40 percent DNOCHP mixture used at 4 ounces in 100 gallons gave 88.1 percent reduction and apparently lacked sufficient wetting agent. A DN dust containing 1.5 percent of the toxicant averaged 95.3 percent reduction when applied from both sides of the tree and reduced the living mites 89.3 percent when the tree was dusted from one side only.

Five tests of spray materials containing rotenone averaged 88.5 percent reduction, including one moderately effective combination which gave only 78.7 percent reduction. A pyrethrum spray containing an excellent spreading agent was one of the most effective materials used and reduced an infestation of 20.04 red mites per leaf to 0.69 live mites per leaf, a control of 97.05 percent. A mixture containing ricin, the toxic ingredient in castor-bean, was the least effective material used. None of the materials caused injury to the fruit, bark, or foliage which was abnormally "hard" following the summer drought.

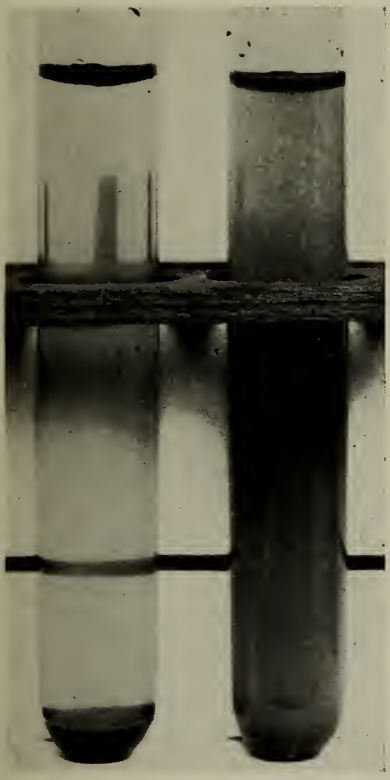


Figure 1

Left: Merrimac fine sandy loam.

Right: Memphis silt loam.

Equal weights of soil dispersed in equal amounts of water and allowed to settle the same length of time.

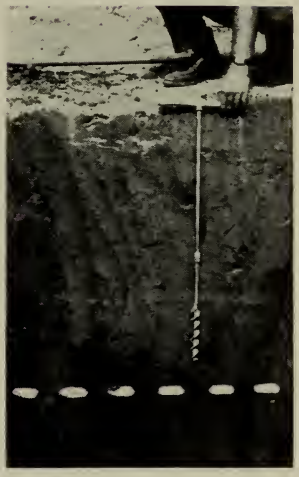


Figure 2

Topsoil 3.5 feet deep, accumulated at the foot of a short cultivated slope through the action of sheet erosion. (Broken white line separates topsoil and subsoil.)

Viburnum

Upper Branch Untreated: Leaves tightly curled, twigs deformed.
Lower Branch Sprayed with DN: Free from aphids, leaves normal.

Defoliation of Rose by the Common Red Spider

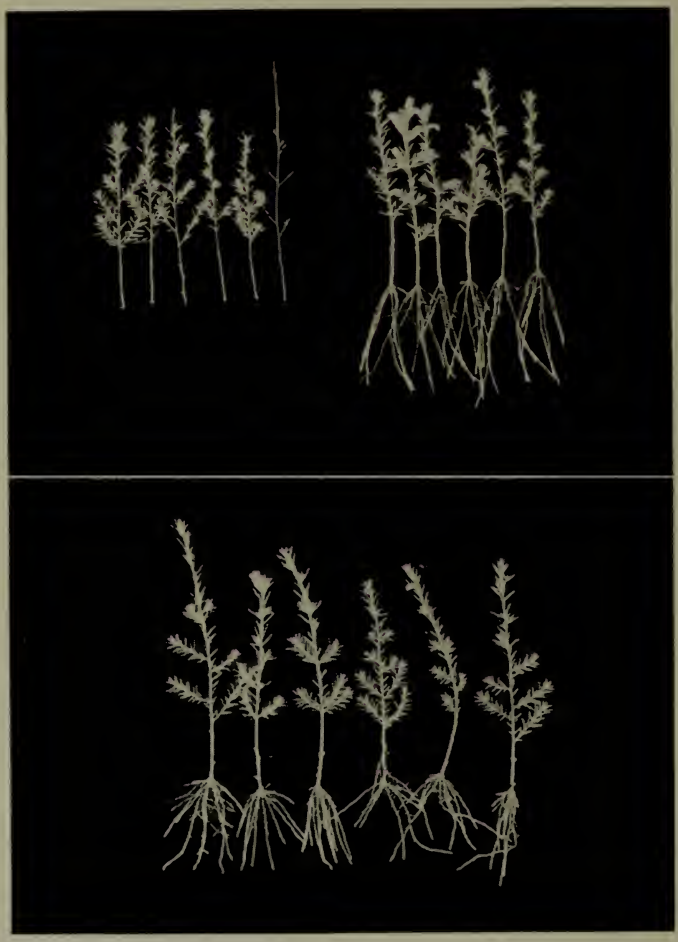
Plant at left sprayed

Plant at right unsprayed

Injury to Ears of Sweet Corn from Oil—Pyrethrum applied for control of Corn Ear Worm

Left: Not treated

Right: Treated



Rooting of Cuttings of Canadian Hemlock

Top: After 10 weeks at 75° F.

Left: Not treated.
Right: Treated with Hormodin A, 30 BTI units for 24 hours.

Bottom: After 15 weeks at 65° F.
Treated with Indolebutryric Acid, 7.5 mg. 100 c. c. for 24 hours.

Summer Sprays for Apples. (A. I. Bourne in cooperation with Departments of Pomology and Botany.) Studies of the value of modifications of the standard spray program were continued. The yield was light, and the prolonged drought in the early season greatly influenced the prevalence of disease, particularly apple scab. The standard spray program, involving lime-sulfur in all sprays through the calyx with wettable sulfur thereafter, was contrasted with a similar program with the addition of a midbloom application of wettable sulfur, and an optional standard in which no lime was used in the cover sprays. The standard schedule was also contrasted with a program of wettable sulfur throughout the season. Lead arsenate was used in all applications except the pre-pink and midbloom sprays. The dosage was 4 pounds to 100 gallons in the calyx, and 1st and 2d cover sprays; 3 pounds in the pink and 3d cover sprays, and 2 pounds in the 4th cover spray. Liquid lime-sulfur was used at the rate of 1½ gallons per 100 and wettable sulfur at 8 pounds per 100 gallons.

The pathologist reported that scab infection was appearing on the foliage of McIntosh check trees in the period of May 23 to 26, and a few infected fruits were observed May 31. On the sprayed trees the spur leaves and fruits were evidently protected by the pre-blossom sprays and the infection was confined to the shoot leaves. The record of McIntosh fruit at harvest supported these observations. The fruit from unsprayed trees showed 44 to 45 percent scab, while on sprayed trees it varied from 0 to 1.8 percent.

The season also was not conducive to spray injury on either leaves or fruit. Distinct injury, however, occurred in all plots where liquid lime-sulfur was applied although this was not of so serious a nature or extent as in years of more normal rainfall. Russeting of fruit was noted in all plots where lime-sulfur was applied.

The control of insect pests was consistent throughout the entire orchard and there was no significant difference between the standard program and the modified schedules. The record of unsprayed McIntosh fruit was illuminating. Three apples, or 0.6 percent were clean; 80 to 81 percent of the fruit was scarred by curculio, and nearly 50 percent damaged by codling moth. Scab occurred on 44 to 45 percent of the apples (in a season very unfavorable for its development). Detailed counts showed that on nearly 50 percent of the fruit there were injuries by three or more insects or diseases on the same apple.

Control of Cabbage Maggot. (W. D. Whitcomb, Waltham.) Definite information showing that one of the largest sources of cabbage maggot flies in the spring is late-planted cruciferous crops was obtained by sifting the soil in a six-inch square and six inches deep around roots of cabbage, broccoli, and turnip which had remained in the ground over winter. These plants were apparently infested by a third generation of the maggot in September. Soil examination on April 18, 1941, showed a maximum of 51 pupae per plant, with an average of 19.9, on a small planting of yellow turnip; a maximum of 14 per plant with an average of 4.9, on a small planting of broccoli; and a maximum of 11 per plant, with an average of 1.9, on a large planting of cabbage.

The first eggs of the cabbage maggot in the spring of 1941 were found on May 1, which is five days earlier than the average date for the past ten years. The normal field infestation was 85.72 percent commercial injury on the Golden Acre variety. One application of corrosive sublimate solution on May 3 gave 92.04 percent commercial protection and yielded 78 percent large and medium heads. Two applications of corrosive sublimate solution gave 96.67 percent commercial protection and yielded 83 percent large and medium heads. Calomel–talc powder containing 4 percent calomel applied at the rate of a teaspoonful around the stem of each plant on May 3 was also satisfactory, giving 100 percent commercial protection and yielding 75 percent large and medium heads.

In 1941 twelve varieties of cabbage were planted to determine their natural susceptibility to cabbage maggot injury. The results indicated that the early maturing varieties such as Golden Acre and the Savoy types were most susceptible, and the red varieties most resistant. Dry weather in the latter part of the growing season interfered with the records on head development, but Red Acre with 64.83 percent large and medium heads withstood the maggot injury and drought the best, while Golden Acre, which suffered the most maggot injury, gave the poorest yield with 7.69 percent marketable heads.

Susceptibility of Cabbage Varieties to Cabbage Maggot Injury, Waltham, Mass., 1941.

Very Susceptible (80 percent or more commercial injury). Golden Acre, Enkhuizen Glory.

Susceptible (65 to 80 percent commercial injury).—Super Curled Savoy, Cornell Early Savoy.

Moderately Susceptible (40 to 65 percent commercial injury). Premium Flat Dutch, All Head Early, Danish Drumhead, Early Jersey Wakefield, Penn State Ballhead.

Slightly Resistant (25 to 40 percent commercial injury).—Mammoth Red Rock, Red Drumhead, Red Acre.

Control of the Squash Vine Borer. (W. D. Whitcomb, Waltham.) The field infestation of the squash vine borer was 7.52 borers per vine, which is one of the greatest infestations ever recorded in the experimental field of Blue Hubbard squash at Waltham. Experimental sprays and dusts were applied July 7, 14, 21, and 28. The sprays were applied at 275 pounds pressure with a small power sprayer, and the dusts with a plunger type hand duster. The most effective treatments were a rotenone–copper oxychloride sulfate dust, white oil emulsion 1 percent with nicotine sulfate 1-500 spray, and nicotine sulfate 1-250 spray. Rotenone–talc dust containing 0.75 percent rotenone and a dust containing 20 percent cryolite with 5 percent metallic copper were moderately effective. Lead arsenate 3 pounds with fish oil 1 pint in 100 gallons of water as a spray was ineffective, this plot having an infestation only 12 percent less than the untreated check.

Yield records showed a significant increase in favor of the dusted plants, reflecting the beneficial action of a fungicide on the production of fruit. The plants receiving the rotenone–copper oxychloride sulfate dust yielded 594 pounds more than the untreated check, an increase of 80 percent. As in previous experiments, there was no consistent direct correlation between yield and borer injury. The 1941 experiments also strengthened the theory that an infestation of 2 borers or less per vine before August 1 does not greatly reduce the yield.

Control of Onion Thrips. (A. I. Bourne.) The early spring was characterized by abnormally warm weather in April and was followed by more normal temperatures in May with very little rain during that period. This was followed by weather somewhat warmer than normal in June and rains which, although for the most part small in amount, were so frequent that field crops such as onions made an early start and grew rapidly.

Such weather conditions would normally favor the early appearance and rapid development of thrips but this was not the case in 1941. In the experimental plots of seed onions, thrips appeared late and developed slowly. There were practically no thrips on the plants throughout June, and by July 14 the average population per plant was only 10 thrips. Very high temperature in early July induced a rapid increase to the peak of 40 thrips per plant on July 21. Following a rainfall of nearly one-half inch on the 25th and a heavy downpour during the 28th (1.9 inches) the number of thrips was reduced to approximately 12 per

plant and remained at that low level until late August when the plants matured. No blast was observed.

Throughout the Valley, fields of both set and seed-grown onions were comparatively free from thrips. Results of tests of contact insecticides for thrips control were inconclusive because of the scarcity of the insects even on the unsprayed plants. Fixed nicotine with a resin residue spreader gave good initial control although its action was slower than that of nicotine sulfate. It was as effective alone as when used with a spreader. A rotenone extract with resin residue spreader had a high immediate effect and good residual action. Derris powder (4 percent rotenone) gave excellent kill within 24 hours, and reinfestation was slow. This was true regardless of the type of spreader used. Nicotine sulfate and soap caused the usual high mortality of thrips within a few hours after application but its residual effect was inferior to that of rotenone.

Predaceous insects were comparatively scarce during the early summer, but by mid-August syrphid flies and predaceous thrips had increased to considerable numbers and contributed very greatly to the rapid decline, in late August, of a very light but long-drawn-out attack of thrips. No evidence of fungus disease of thrips was observed.

The Spray Residue Problem. (A. I. Bourne.) The more liberal limits of tolerance established in the late summer of 1940 continued in effect for the shipping season of 1941. While the present limits are calculated to allow the growers greater latitude in their pest control program, the prolonged drought from late July until harvest and the uncertainty as to the permanency of the present limits made growers reluctant to enlarge their spray program, and for the most part very few changes were made. In the spray program recommended by the college for 1941 the only significant change was the suggestion of a 75–25 sulfur–lead arsenate dust as an alternate for the 2d cover spray.

Through the cooperation of the Control Service, analyses were made for lead and arsenic residue on samples of McIntosh collected from the sprayed plots at harvest. These analyses showed the amount of residue to be in all cases well below the present limits.

Fruit which had received the standard schedule recommended for the State showed residues of .031 grains of lead and .013 grains of arsenic per pound of fruit. Samples from the optional standard schedule in which no lime was used in the cover sprays gave .026 grains of lead and .009 grains of arsenic per pound. In the plots where wettable sulfur was used throughout the season, the lead residue ranged from .023 to .037 grains per pound and the arsenic residue from .005 to .015 grains. Lead arsenate was applied in the 2d cover spray (June 10) at 4 pounds per 100 gallons; 3 pounds in the 3d cover (July 2); and 2 pounds in the 4th cover (July 29). The fruit was picked September 15. While the total precipitation for July was nearly normal, approximately half of it occurred in one shower on the 28th. Records showed that during August and September little more than half the normal rainfall occurred, a deficiency of 3.67 inches. Fruit encountered unusually favorable conditions for the retention of spray deposits and normal weathering off could not take place.

Even under such a severe test as the past season offered, lead and arsenic residues were so far below present limits that there was a substantial margin of safety, which would indicate that if these limits are retained the growers will have more latitude for stiffening their spray schedule for late summer pests than they have enjoyed since spray residues became a problem of major importance.

Apple Maggot Control. (A. I. Bourne and W. D. Whitcomb.) Apple maggot proved to be of relatively minor importance in 1941, not only in Massachusetts but throughout most of the Northeastern States. In well-sprayed commercial

orchards the injury was negligible, and even in the smaller home orchards which received little attention the pest was not conspicuous.

This reduction is not believed to be due to any marked increase in energy on the part of the growers or to any improvement in the handling of dropped fruit or other precautionary measures. It is the general belief that adverse weather conditions and especially deficient rainfall at the period of normal emergence of the flies were the chief contributing factors.

In the emergence cages at Waltham the flies began to appear on June 19 which is the earliest date since the observations were started. Although the cages were operated in the same way as in the previous years, the emergence in the cultivated cage was greater than usual and that in the sod much smaller than usual. This condition is apparently correlated with the deficiency of soil moisture this year. The emergence record is as follows:

	In Sun — Light Soil	
	Cultivated	Sod
Degree of Emergence:		
First fly	June 19	June 24
25%	June 30	July 3
50%	July 7	July 9
75%	July 12	July 15
100%	August 7	July 27
Number of larvae in 1940	400	400
Number of flies emerged 1941	207	43
Percent emergence	51.75	10.75

Insecticides for the Control of European Corn Borer. (A. I. Bourne and W. D. Whitcomb.) The unseasonably warm weather throughout April promoted abnormally early pupation of the overwintering corn borer larvae. Seasonable weather in May allowed development to progress normally and resulted in a very early emergence of the spring brood of moths. On the other hand most of the growers planted corn at the usual time, with the result that considerable moth emergence took place before corn was above ground or at least when it was too small to be attractive for oviposition. In addition, during much of the time that the moths were present the temperatures at dusk were too low for moth activity. As a result the infestation by first generation larvae was negligible throughout the State. Growers harvested very clean corn even where no control measures were practiced, and in fields which were sprayed or dusted there was slight evidence of the borer.

In the experimental fields the plots sprayed with derris and Ultrawet showed 4 infested ears out of 660, 99.4 percent clean corn, 84.5 percent of which was grade 1 or 2; in other words, 84 percent of the total yield was marketable grade. A fixed-nicotine spray gave 97.1 percent clean corn, 84 percent of which was marketable. In the plots dusted with derris there were 4 infested ears in a total of 652, 99.4 percent clean corn, 90 percent of which was of marketable grade. Dual-fixed nicotine dust gave 98.8 percent clean ears, and 84 percent of the total yield was of marketable grade. The infested ears were so few that the grower made no effort to salvage them. The unsprayed check plots yielded a total of 682 ears, 48 of which were infested. In other words the infestation was so light that 92.9 percent of the yield was free from borers. In the entire field, regardless of treatment, only 83 ears out of 3,341 examined were infested. No attempt was made to spray late corn because of the scarcity of 2d brood larvae.

The infestation by the first generation of the European corn borer in the experimental planting at Waltham was so light that results of spray applications

were not significant. In the check plot there were 5 infested non-salable ears and 5 infested but salable ears in a yield of 203 ears. Hills sprayed individually with a mist nozzle showed 1 infested but salable ear in 219 ears, and the block sprayed with a spray gun from the border showed 2 infested salable and 2 infested non-salable ears out of 226. Powdered derris root 3 pounds and Ultrawet ½ pound in 100 gallons was used June 17, 24, 30, and July 7.

The second generation planting at Waltham was not sprayed because of the light infestation, and an examination on August 21 showed 15 infested ears or 1.34 percent in 1,118 ears examined.

On August 12 a part of this corn was treated for protection against the corn ear worm, by applying a standard lubricating oil–pyrethrum solution to the dried silk of the ears. No corn ear worm infestation developed but the treatment injured the ears by preventing pollination of the kernels in the terminal portion of the ear, indicating that this treatment is not satisfactory under all conditions. (See page 55.)

Potato Spraying Experiments. (A. I. Bourne.) The weather conditions during spring and early summer furnished a very favorable start for potatoes and allowed them to keep this initial advantage. The plots were planted on May 9. The plants appeared promptly and growth was steady and rapid throughout the summer. The plants were slightly damaged by a light frost on the night of September 19-20 and were killed by a heavy frost on September 29-30. The crop was dug September 30 to October 2. In all of the plots sprayed with bordeaux the plants were alive, green, and thrifty until killed by frost.

Leafhoppers were very few and no outbreak occurred at any time during the season. Potato aphids became abundant in early July but were controlled by the addition of nicotine in the spray of July 16 and never threatened thereafter. Flea beetles were abundant throughout June and early July; the late July infestation was not so heavy. In the experimental plots 11 applications were made between June 11 and August 27. A new method of determining flea beetle injury was devised by which the number of feeding punctures was correlated with the amount of leaf growth. The plan was designed to show the amount of injury from week to week as well as the cumulative damage throughout the season. On this basis the amount of flea beetle feeding in the plots given a commercial spray of basic copper sulfate and sulfur was 103.1 feeding punctures per square inch of leaf surface; plots which received a basic copper arsenate–sulfur compound showed 45.1 feeding punctures per square inch of leaf surface; and the plot which received a neutral insoluble copper fungicide (double copper) showed 88.6 punctures per square inch.

In all the plots sprayed with home-made bordeaux mixture the damage from flea beetle feeding was very much less than that in the plots receiving commercial sprays. There was a slight advantage in favor of the low-calcium bordeaux, and the addition of calcium arsenate in every case furnished added protection.

The length of life of the plants in the different plots was in exact proportion to this index of beetle activity. The plants sprayed with basic copper sulfate and sulfur began to die early in August and by the end of the month practically all were dead. Plants in the plot given the basic copper arsenate–sulfur compound succumbed somewhat later. The plants given the neutral copper fungicide remained alive until mid-September. In all of the bordeaux-sprayed plots most of the plants were alive and green until the frosts of late September.

The summer was marked by a prolonged drought, and the lack of sufficient moisture interfered very seriously with the growth of the tubers and yields were proportionally reduced.

The yield records, however, showed a direct correlation with the amount of flea beetle injury. In the plots which received the commercial sprays, yields

of 308 to 346 bushels per acre were recorded, while plots in the same field which received bordeaux mixture yielded 420 bushels per acre. The plot which received the low-calcium bordeaux plus calcium arsenate gave the highest yield—474 bushes per acre, 76 percent of which was of number 1 grade.

Introduction of Parasites of Oriental Fruit Moth in Peach Orchards. (A. I. Bourne.) The work of rearing parasites of the oriental fruit moth was continued in 1941. By agreement with the Department of Entomology of the Connecticut Experiment Station, Mr. A. DeCaprio was again placed in charge of the collection and shipment of breeding material for both institutions. Parasitism was comparatively high in the New Jersey strawberry fields in 1941 and the season was early. Mr. DeCaprio, by benefit of his experience in past seasons, was able to locate superb fields for collection. Cool weather during the shipping period and rapid transit allowed the material to arrive at the laboratory in Amherst in very good condition.

The strawberry leaf roller larvae were very nearly full grown when collected so that very little migration took place after arrival in the laboratory. Emergence of the parasites was such that all the orders from growers were filled by June 30, and within the next few days a sufficient number of parasites emerged to duplicate all original orders, fill late orders, and in most cases duplicate these. The surplus material for distribution was made possible by the very proficient work of Mr. DeCaprio in collecting breeding material, the very accurate estimates of parasitism, and the improved technique in the laboratory. Fifty-eight growers in 9 counties received a total of 140 colonies. More than half the growers received their orders in half colonies to facilitate more uniform distribution in large orchards or for use in small, isolated blocks.

The warm weather, the unusually large number of hours of bright sunshine, and the few rainy days during the period of liberation offered very favorable weather conditions for the parasites.

Naphthalene and Similar Compounds as Greenhouse Fumigants. (W. D. Whitcomb and Wm. Garland, Waltham.) A complete series of experimental fumigations with a mixture of monochlor naphthalene oil 3 parts and commercial flake naphthalene 1 part indicated that the vaporization of ¾ to 1 ounce of the fumigant in 1,000 cubic feet constitutes a lethal atmosphere which will kill 80 percent or more red spiders if they are exposed for three hours. These results were obtained when the experiment was made at a constant temperature of 70° F. and a relative humidity of 50 percent, and also at 75° F. and 60 percent humidity. At the higher temperature and humidity the mortality was about 3 percent higher, especially at the shorter exposures.

A mortality of 30 to 40 percent resulted when the spiders were exposed for three hours to ¼ to ½ ounce per 1,000 cubic feet, and an exposure of one or two hours to a lethal atmosphere killed only 15 to 25 percent. Potted carnations heavily infested with the common red spider mite supplied the experimental material, and the fumigant was vaporized at the rate of ¼ ounce per 1,000 cubic feet each hour for six hours. An infested plant was entered and removed each hour during the fumigation.

Control of the Common Red Spider on Greenhouse Plants. (W. D. Whitcomb, Wm. Garland, and W. E. Tomlinson, Jr., Waltham.) Life history studies of the red spider on different host plants at constant temperatures were continued. Most of the studies were on potted snapdragon and showed that the time required for development at 60°, 70° and 80° F. was approximately in a 3:2:1 ratio as follows:

	Average Number of Days at —		
	60° F.	70° F.	80° F.
From oviposition to hatching	14.48	7.71	3.81
From hatching to adult—male	15.70	9.46	5.35
female	19.17	11.00	6.25
From oviposition to adult—male	30.94	16.95	9.23
female	31.41	18.62	10.00

Oviposition records showed that although the female spiders laid about as many eggs at 60° F. as they laid at 70° and 80° F. in this experiment, they required about ten times as long to lay them.

Studies of red spider development on various host plants continue to indicate that there is some plant character which determines the rate of spider development, and studies to determine this are planned.

Spraying experiments with eleven advertised insecticides recommended for combating the red spider mites on roses were applied at weekly intervals in three series, using a greenhouse power sprayer at 275 pounds pressure. Of these, one material was very effective and outstanding; two were moderately effective and satisfactory; and eight were unsatisfactory. (See page 55.)

The most effective material is described as Technical Mannitan Monolaurate to which 1 percent rotenone and 1.8 and 2.6 percent other derris extractives have been added. When diluted to 1-400 this was the only spray material which reduced a natural infestation of 25 to 50 spiders per leaf to less than 5 live spiders per leaf, and consistently killed 90 percent or more of the spiders without injury to the plants. When diluted 1-600 this material was less effective but gave satisfactory control.

The other satisfactory materials, which combined rotenone and emulsified dispersing oils, reduced the infestation 60 to 80 percent and permitted 10-18 live spiders per leaf after treatment.

Unsatisfactory materials included rotenone combined with chlorinated heterocyclic hexylamine, powdered derris root and sulfonated castor oil, a commercial flour paste, monochlor naphthalene soap emulsion, a commercial preparation containing castor bean extract (ricin), and rotenone combined with hydrous aluminum oxide. Several of the rotenone sprays which gave unsatisfactory control of the red spider mite on roses gave excellent control of the same pest on potted carnations.

Three applications in March of a dinitro dust containing 1 percent dinitro-ortho-cyclo-hexylphenol killed 90 percent of the red spider mites and reduced an infestation from 25 to 2.4 live mites per leaf without injury to the foliage.

Biology and Control of the Apple Leaf Curling Midge. (W. D. Whitcomb, Waltham.) Although a strong northeast storm occurred on June 5 while the midge flies were still plentiful and might have been blown a considerable distance to the southwest, no new infestations outside of the previously known infested area were discovered or reported. However, this midge was found within the infested area in several orchards where it was not known to be present before 1941.

In the insectary the transformation to flies was 22.54 percent from maggots collected in June 1941, 45.41 percent from maggots collected in July and 11.11 percent from maggots collected in August.

In the observation orchard at Westford the infestation was very heavy during May and June but, because of the drought and absence of late summer growth even on watersprouts, it was below normal in late July and August. Records of 2117 bud tips on Baldwin trees examined at regular 3 and 4 day intervals between May 9 and September 12 showed that eggs were laid on 1712 or 80.87 percent of them. Oviposition was concentrated in three distinct periods when

eggs were found on every bud examined, namely May 27 to June 10, July 1 to 8, and July 22 to August 5. During the first two periods 100 tips were examined at each observation; but in the last period the number of tips available averaged less than 10, contrasted with 1940 when a large number of tips was available until about August 25. In 1941 the first eggs were found on May 9 which is 15 days earlier than in 1940.

Maturity of larvae and their emergence from rolled leaves was concentrated in three definite periods on June 17 to 24, July 8, and July 29. These periods generally correspond with the rainfall rather than with the development of generations which was extended and overlapped by abnormal weather conditions. The relative abundance of the midge throughout the summer is indicated by the number of larvae collected in 5 bands as follows: June 17, 2280; July 8, 244; and July 29, 790.

In a newly infested orchard at Waltham containing 96 trees of 7 varieties of approximate equal exposure to infestation, 893 infested buds were collected on June 12. The average number of infested tips per tree of each variety was: Delicious, 42.00; Rhode Island Greening, 8.75; Baldwin, 7.58; McIntosh, 4.54; Gravenstein, 3.16; Northern Spy, 0.33; and Wealthy, none. In this collection 63.29 percent of the infested tips were found on the Delicious trees. Another collection on July 9 yielded 532 infested tips on the same trees, making a reduction of 40.42 percent due to destruction of the maggots in the infested tips at the previous collection.

Similar collections from a nearby orchard where 396 infested tips were collected on 54 small trees showed an infestation of 11.94 tips per tree or 57.32 percent of the total on Starking; 6.00 per tree on Golden Delicious; and 3.58 per tree on Baldwin. In a block of young trees, 2 Milton trees had an average of 24.5 infested tips, indicating high susceptibility. At the same time no infested tips were found on 15 Macoun trees.

Continued experiments with naphthalene broadcasted at the rate of 2 pounds per 100 square feet showed that the treatment reduced the number of midge flies emerging from the soil and duff 79 percent at the first generation and 97 percent at the second generation.

Larvae and pupae in cocoons under the rough bark on the trunk of the trees were killed by experimental spraying with dormant sprays. Applications to the bark were made April 11 and July 1 using Elgetol (Standard Agricultural Chemical Company) 1 percent, Spra-Cream (B. G. Pratt Company) 3 percent actual oil, and Spra-Cream 3 percent plus DNOCHP (Dow Chemical Company) 15 ounces per 100 gallons. Cages enclosing 3 feet of the tree trunk were built around the sprayed trees. In these cages 84 flies of the first generation and 40 flies of the second generation were collected from the unsprayed tree, while only 2 flies were found in any of the cages on sprayed trees. Emergence of flies from mulch collected under trees where the above dormant sprays were applied at the rate of 2 gallons per 100 square feet indicated that considerable mortality of the midge resulted where Elgetol was applied but that the oil emulsion treatment was not effective.

Control of Plum Curculio in Apples. (W. D. Whitcomb, Waltham.) In spite of unseasonably warm weather during the pre-blossom and blossom period of apples, the critical period of curculio activity did not occur until May 20-23 which was five to eight days after the petal-fall stage. This period was characterized by maximum temperatures above 85° F., but it was apparent that the suitable development of the fruit for feeding and oviposition was the most important attraction to the beetles.

Blocks of eight trees each were sprayed with lead arsenate 4 pounds, wettable

sulfur 4 pounds, fish oil 1 pint in 100 gallons of water when the fruit was 4/16, 5/16, and 6/16 of an inch in diameter, as determined by the measurement of 200 apples with calipers.

Variety	Diameter of Apples		Date Sprayed	Apples Stung (Percent)
	Estimated (Inches)	Actual Average (Inches)		
Wealthy	4/16	4.10/16	May 20	18.72
	5/16	5.10/16	May 22	8.12
	6/16	5.94/16	May 23	18.70
McIntosh	4/16	3.84/16	May 20	11.53
	5/16	4.99/16	May 22	3.88
	6/16	5.92/16	May 23	5.42

These records, based on the examination of 57,835 apples, show least injury by the plum curculio to apples sprayed when they measured approximately 5/16 of an inch in diameter. This difference is the more significant since the "5/16" trees were located near a stone wall and fence row where much curculio injury has occurred in the past. In the Wealthy apples the curculio injury was 1 percent greater on dropped fruit than on picked fruit; but in McIntosh the dropped fruit showed 3 to 12 percent more injury.

Biology and Control of the Grape Plume Moth and Grape Cane Girdler. (W. D. Whitcomb and Wm. E. Tomlinson, Jr., Waltham)

Grape Plume Moth. A study of the parasitism of the grape plume moth yielded two new species (undetermined), but the total parasitism in the larvae collected was less than 1 percent.

The application of dormant sprays on April 10, just before the larvae hatched, showed that dinitro compounds are more effective than oil emulsion. In one experiment the addition of a DNOCHP compound at the rate of 15 ounces in 100 gallons increased the control from 74 to 86 percent over oil emulsion at the rate of 3 percent actual oil; and in another experiment the addition of DNOC (15 ounces-100 gallons) to 3 percent oil emulsion increased control from 60 to 82 percent. The best control was obtained with a commercial sodium dinitro cresylate 1 percent which gave 94 percent protection. When this material was used at ½ percent dilution the infestation was 12 percent or twice that following the use of the 1 percent dilution.

Grape Cane Girdler. The first activity of the grape cane girdler was observed on May 22 when the maximum temperature was 89° F. The average life of 26 individuals from egg deposition to adult in bagged canes in the vineyard was 60.8 days with most of the beetles emerging from August 15 to 25 but continuing until September 22.

In the vineyard, beetles were reared from 28 percent of the girdled canes under observation and this seemed to be a normal survival under the conditions.

Measurement of 100 canes showed that the average growth from May 22 to July 2 was approximately 1 inch per day, with Niagara and Fredonia making the most rapid growth and Delaware the least.

Sprays applied when the average cane growth was 4 inches or less prevented most girdling, but when the growth between sprays was about 8 inches the number of girdled canes was 8 to 15 percent greater than on the unsprayed vines. Cryolite at the rate of 3 pounds in 100 gallons was more satisfactory than lead arsenate, which caused some foliage injury when combined with sulfur or copper oxide in frequent applications.

Insects Concerned in the Dispersal of Dutch Elm Disease. (W. B. Becker.)

The Smaller European Elm Bark Beetle, Scolytus multistriatus Marsham. Elm logs in Alford, reported by the owner to have been cut just prior to April 1941, were found to contain only large larvae of *Scolytus multistriatus* at the end of September. No emergence holes could be found. If the time of cutting was given correctly, the size of the larvae present would suggest that one generation a year may be common in this region of the Berkshires. Logs of both American elm, *Ulmus americana* L., and slippery elm, *Ulmus fulva* Michx., were heavily infested. In an adjacent area, elm logs reported by the owner to have been cut at various times from the early spring through late fall of 1941 showed the presence of brood galleries in all stages of construction. Completed brood galleries containing large larvae, galleries with small larvae, and incomplete galleries with only eggs and active parent beetles were found.

The Native Elm Bark Beetle, Hylurgopinus rufipes (Eich.). At the end of September 1941, other elm logs in Alford which were reported by the owner to have been cut just prior to April 1941 contained larvae, pupae, and young adults of *H. rufipes* and many emergence holes. These logs were adjacent to those cut at the same time which were infested with *S. multistriatus*. The evidence suggests that in this vicinity *H. rufipes* beetles which develop from the first eggs laid in the spring may complete their development sooner than *S. multistriatus* beetles.

Insects Observed in the First Tree in Massachusetts Found to have Dutch Elm Disease. (W. B. Becker.) Numerous feeding or overwintering tunnels of *H. rufipes* were observed in the tree, especially near the base. Adult beetles were active in these tunnels in mid-September. Such tunnels, of course, are commonly encountered in live elm trees. No correlation was determined between the occurrence of these tunnels and the presence of the fungus, *Ceratostomella ulmi* (Schwarz) Buisman, in any part of the tree.

Scouting for Elm Bark Beetles. (W. B. Becker.) Brief scouting revealed the presence of *Scolytus multistriatus* at three locations new to this office: Concord, Alford, and Hancock, Mass.

At Alford, in the vicinity of the first tree in Massachusetts found to have Dutch elm disease, this beetle was abundant in elm logs on an area being cut over for cordwood. *Hylurgopinus rufipes* was also abundant in the vicinity of the diseased tree.

The Effects of Solar Heat on the Subcortical Development of the Native Elm Bark Beetle, Hylurgopinus rufipes (Eich.) at Amherst. (W. B. Becker.) Laboratory and field work on this problem was continued.

Insect Pests of Wood and Shade, Forest, and Ornamental Trees in Massachusetts. (W. B. Becker.) Three hundred and one inquiries were received about such insect pests. Eighty-four different kinds of insects were involved. Ants, powder post beetles, termites, spruce gall aphids, elm leaf beetles, and secondary tree-boring insects were received most frequently.

DEPARTMENT OF FLORICULTURE

Clark L. Thayer in Charge

Breeding Snapdragons for Varietal Improvement and Disease Resistance. (Harold E. White, Waltham.) Plants propagated vegetatively from Field Station rust-resistant strains of commercial hybrid snapdragons have been tested two summers under field conditions and in the greenhouse for two winters. These strains were highly resistant to rust disease; a wide range of flower colors was present, and growth and flowering habit were excellent. Many of these hybrids are still segregating for rust susceptibility and are heterozygous for flower color.

A few selections from seeded lines look promising as material for developing pure breeding forms for rust resistance and desirable flower colors. In earlier breeding work with Main's hybrids considerable difficulty was experienced in getting rust resistance bred into such selections and at the same time retaining desirable flower colors, growth habits, and blooming period in the same strains. It was anticipated that with the commercial variety hybrids this combination might be more readily developed into desirable pure-bred lines.

These hybrids are available now, provided florists are interested in growing snapdragons by propagating such strains from cuttings.

Cultural Requirements of Freesia. (Harold E. White, Waltham.) Records on the pre-curing or drying of freesia corms (⅝ to ¾ inch size), for a period of 3 to 11 weeks prior to planting, show that by this treatment in 1939 corms lost from 3 to 24 percent of their weight; in 1940, 3 to 20 percent; and in 1941, 7 to 21 percent. Corms of Golden Daffodil (⅝ to ¾ inch) in the 1940 treatment failed to sprout unless pre-cured for 3 weeks prior to planting. Corms of this variety received the same pre-curing treatment in 1941 but responded normally, which would indicate that, although the pre-curing treatments of the corms in 1940 overcame the growth inhibition factor, this same peculiarity was not present in the 1941 stock.

Loss in moisture content of freesia corms through pre-curing treatments has not been found to have any significant effect on the blooming or production characteristics of the corms. At a temperature of 48°-50° F., corms grown in benches flowered a week to ten days earlier than those grown in bulb pans. Early and later planted corms in bulb pans, shifted in November from a temperature of 50° F. to 60°F., flowered two weeks earlier on an average than those continued at the cooler temperature.

Results of tests in pre-curing freesia corms for periods of 2 to 11 weeks prior to forcing indicate that such treatments are not essential for successful forcing of freesias in the greenhouse. It is concluded that seasonal and cultural treatments given the freesia corms in the field are more likely to determine their forcing performance.

The use of well-rotted manure in soil mixtures for freesias has not had any harmful effect on the growth or flowering of the corms.

Foliage tip-burn of freesia plants may be caused by fumigants and by fluctuations in temperature, soil moisture, and humidity. Contrary to general opinion, freesias will take plenty of water when well rooted in properly drained soil and growing normally.

Elder's Giant White was observed to be a much slower growing type than Purity, Golden Wonder, or Golden Daffodil.

Soilless Culture of Florists' Crops. (Harold E. White, Waltham.) This system of plant culture has been conducted primarily as a demonstration for growers and to determine how much attention must be given to such a system to obtain crop production comparable to results from soil culture.

Carnation plants have responded equally well to some four to six nutrient formulas which have been tested. It is apparent, at least with carnations, that a considerable degree of adaptability to nutritional levels exists under soilless culture conditions, which is likewise true for plants grown in soil.

Root rot and stem diseases of carnations can be just as prevalent and destructive under gravel culture methods as in soil, particularly soon after the plants are set. Much of the danger lies in keeping the plants too wet rather than too dry. Tobacco and naphthalene fumigants can be used on carnations in gravel, following the same precautions necessary for successful fumigation of plants in soil.

New England growers have shown little inclination to grow flower crops in gravel, even on a trial basis. One grower, who last year was favorably impressed with the results from 350 square feet of soilless roses, has expanded to 2,500 square feet. At Waltham cinders, which for two years were used in growing roses, are now being used for the culture of carnations.

Liming Carnation Soils. (Harold E. White, Waltham.) Data for two years on the use of lime on carnation soils to determine the importance of soil acidity as related to plant growth and flower production show that carnations have a wide degree of adaptability to changes in soil acidity. The average acidity test of soil used for carnations was pH 5.6; the final acidity readings over a period of two years were 4.7 for unlimed and 6.4 for highly limed soils. While this test does not cover extreme ranges in acidity or alkalinity, it does pertain to normal variations of growers' soils as observed from soil testing records of five years at the Waltham Field Station.

There were no significant differences in flower production, number of split calyces, or vegetative plant growth between plants in unlimed soil and those in soil receiving applications of lime at the rate of 1 to 3 tons per acre.

Plants of the variety Ward were used in these tests and the same cultural treatments were given both years. Cultural and seasonal climatic conditions were of greater importance than soil treatments in their effect on crop production. The greater incidence of split calyces occurred between the months of January and April. During the season of 1940-41 plants produced only 2 percent more split calyces than during the previous season.

Field-grown plants produced four more flowers per square foot of bench area than greenhouse-grown plants. Since liming of soils had no perceptible effect on prevalence of root or stem rot diseases, the common practice of applying lime to correct or inhibit the spread of these soil organisms may be considered of little value for the purpose.

Disease Resistance and Heredity of Carnations. (Harold E. White, Waltham.) This work is merely getting under way. Thirty-five varieties have been assembled for study. The selfing of different varieties and experiments in germination of pollen are in progress.

In some preliminary breeding work in 1939–1940 a cross between the varieties Ward (pink) and Puritan (white) gave a progeny of 45.83 percent white flowers, 36.45 percent pink, 2 percent red, and 15.62 percent variegated flowers. The flower types were 8.24 percent singles, 56.70 percent commercial (normal) doubles, and 35.05 percent bursters or split calyx types. Short-calyx flowers were dominant over long or intermediate types. Broad-leaved characters of plants were dominant over narrow and medium leaf characters. These observations show, as was expected, that the commercial types of carnations are heterozygous for many of the plant characters to be studied in this project.

Coffee Chaff as a Soil Amendment. (Harold E. White, Waltham.) Inquiries are frequently received from manufacturing concerns as to the possible use in

greenhouse soils of certain waste organic by-products; when convenient, these materials are tested on the current-year crops at the Field Station.

Coffee chaff received from Wetmore and Company, Cambridge, Mass., was incorporated into carnation and snapdragon soils at the rate of two inches of the chaff to six inches of bench soil with no harmful effects to the plants. Also, it appeared to be quite suitable for use in potting soils and as a filler and conditioner in fertilizer mixtures.

According to the analyses of the Fertilizer Control Laboratory of the Experiment Station, one ton of coffee chaff has a trade valuation in terms of plant food of approximately $10 to $11.

Packet Seed Studies. (Clark L. Thayer.) For a sixth season the Department of Floriculture has cooperated with the Seed Laboratory in a test to determine the quality of flower seeds sold in retail seed stores, chain stores, schools, and other retail outlets. The seeds were tested for germination and performance under field conditions.

The test included 218 lots, representing 50 genera, packeted by 32 concerns, and obtained from 80 retail outlets. Records on germination showed 124 lots good; 55 lots, fair; 31 lots, poor; 8 lots, none. Records on performance showed 165 lots, satisfactory; 12 lots, fair; 41 lots, not satisfactory. Detailed results are reported in Control Series Bulletin 111.

Floriculture Soil Testing Service. (Harold E. White, Waltham.) The following tabulation shows the number of soils tested in 1941:

Roses	132
Carnations	508
Chrysanthemums	157
Gardenias	74
Snapdragons	106
Sweet peas	32
Miscellaneous	573
Total	1582

DEPARTMENT OF HOME ECONOMICS NUTRITION

Helen S. Mitchell in Charge

Vitamin Requirements of Older People. (H. S. Mitchell and A. W. Wertz.) Very little is known concerning vitamin requirements with advancing age. The favorable reports of the clinical application of vitamins, particularly thiamin, in geriatrics raise the question as to why such deficiencies exist. This study was undertaken with the hope of arriving at a better understanding of vitamin metabolism in older people. The project is partially sponsored by Standard Brands Incorporated.

Work now in progress concerns the correlation between cardiac changes, blood hemoglobin, red cell count, differential red cell count, and thiamin excreted in the urine, with the intake of pure thiamin versus the entire vitamin B complex. If possible the bisulfite-binding substances in the urine and pyruvic acid in the blood will be determined also.

Thiamin and Pyrimidine Studies on Older Subjects. (A. W. Wertz and H. S. Mitchell.) (*Proc. Soc. Exp. Biol. and Med.* 48: 259, 1941.) Four men and four women between the ages of 65 and 75 years were used as experimental subjects

in this study. The yeast fermentation method was used to measure the urinary excretions of thiamin and pyrimidine for each individual on graded levels of thiamin intake. There appears to be a sex difference in the excretion of thiamin which is not apparent in the excretion of pyrimidine. The response of people in this age group to increased thiamin intake is similar to that of younger people as far as excretion is concerned. Two out of eight subjects reported no subjective reaction to increased thiamin intake, two noted definite improvement in chronic constipation, four felt less fatigued or "peppier," two enjoyed improved appetites, and one noted an increased thirst.

Cause and Control of Nutritional Cataract. (H. S. Mitchell, G. M. Cook, and A. W. Wertz.) The experimental production of cataract in rats by feeding rations containing galactose has become a means of studying the effect of various dietary factors upon the lens. Since it has been well established by earlier work in this laboratory that a deficiency of protein aggravates cataract development and that a liberal supply delays it, the question naturally arose as to what factor in protein is responsible for the protective action. Anti-cataractogenic action of certain nitrogenous factors is being studied.

1. *The Influence of Certain Diamino and Dicarboxylic Amino Acids upon the Cataractogenic Action of Galactose.* (H. S. Mitchell and G. M. Cook.) Following the lead suggested by work reviewed in the 1940 Annual Report, certain individual amino acids are being investigated. It was reported that the enzymic hydrolysate of deaminized casein was somewhat more protective than the deaminized casein from which it was prepared. Of the fractions, the diamino-dicarboxylic acid fraction of the enzymic hydrolysate afforded as much protection as the whole hydrolysate, while the monoamino and proline and peptide fractions showed no protection. Since glutamic acid, histidine, arginine, and lysine are present in the protein hydrolysate fraction found to be most protective, these amino acids have been incorporated in a low-protein galactose ration in order to study any protective action. One of these amino acids has indicated slight protection. It and related compounds are being studied further.

2. *Time Factors in the Development of Galactose Cataract.* (G. M. Cook and H. S. Mitchell.) It has been observed in this and other laboratories that young rats are more susceptible to galactose injury than older rats. An experiment designed to investigate the question of this age factor is in progress. Rats from the same litter are started on experimental rations at fortnightly intervals. The one started later required a longer time for lenticular injuries to become evident. The complete data are not yet available.

The injury due to galactose seems to persist in rats after they have been transferred to rations containing none of this sugar. The blood sugar returns to normal within a few hours after the ration change is made. The apparent lag in the galactose injury must be due to slow diffusion from eye fluids. The extent of this lag is being investigated by discontinuing the galactose ration at four-day intervals in a series of rats from the same litter.

The Nutritive Value of the Iron of Cocoa and Iron-Fortified Cocoa Mixtures. (F. Kinder and H. S. Mitchell, with the cooperation of W. S. Mueller of Dairy Industry.) Inasmuch as iron is precipitated in the presence of tannic acid and from 2 to 15 percent of tannic acid is present in commercial cocoa, there arises the question of the availability of the iron in cocoa and foods associated with it. The current use of chocolate milk and chocolate-flavored foods makes the problem one of practical interest.

The nutritive value of the iron of cocoa and iron-fortified cocoa was determined by biological procedure. The iron of cocoa was not so well utilized (approx-

imately two thirds as much hemoglobin regenerated) as an equivalent amount of ferric chloride. The addition of pure tannic acid did not decrease the utilization of iron added to a milk ration. Iron added to cocoa was completely available, indicating that the factor which limited the nutritive value of the iron of cocoa had no influence on added iron. Both cocoa and tannic acid retarded the growth of rats, but the effect of the tannic acid was less severe than that of the cocoa.

It may be concluded from this study on rats that cocoa may be fortified successfully with iron. However, the indiscriminate use of chocolate or cocoa milks is not recommended because of the yet unexplained effect of cocoa on growth and intestinal function.

Effect of Adding Cocoa to Cow's Milk on Utilization of Calcium and Phosphorus. (M. R. Cooney, with the cooperation of W. S. Mueller of Dairy Industry.) Interference with the solubility of calcium and phosphorus is a matter of concern when cocoa is added to milk, since cocoa contains oxalic acid, which if present in large enough amounts may prevent the absorption of calcium by the formation of insoluble calcium oxalate.

Accepted standard biologic and chemical procedures are being used to determine whether or not the utilization of calcium and phosphorus is impaired by the addition of cocoa to milk. Results are not yet available.

The Influence of College Life on the Physical Status and Food Habits of Massachusetts State College Women Students. (M. S. Gutowska and E. B. Ellms, Department of Student Health.) In order to determine the physical and nutritional status of the women students, a study is being conducted of the basal metabolic rate, the creatine output, and the urine and blood picture of the freshman women students. A general medical examination is the starting point of this study. The dietary habits of the girls as well as their daily intake of calories and protein are recorded through individual computation. Sixty cases have been investigated thus far.

These determinations provide material for an evaluation of the physical status of the women students, and it is planned to continue them for the next three college years.

DEPARTMENT OF HORTICULTURAL MANUFACTURES

C. R. Fellers in Charge

Cranberry Research. (C. R. Fellers and A. S. Levine.) About 25 percent of the cranberry crop is now used for canned or other manufactured products. Cranberry juice and cranberry sauce were shown to be definitely bacteriostatic for many bacteria of the food-poisoning group. There were also indications that these foods had a marked cleansing action in the mouth.

Cranberries contain small amounts of riboflavin, pantothenic acid, and thiamin not previously reported.

In sauce manufacture, the extraction of the berries with water at 185°-195° F. for 20-25 minutes resulted in increased yields of sauce over the usual short-time extraction at the boiling point. The pectin is conserved and a sauce of improved quality results.

A new concentrated sirup was prepared by first cold-pressing the juice, treating with Pectinol to revive pectin, filtering, and concentrating in vacuum. This sirup serves as a beverage base or as a pharmaceutical vehicle.

Apple Products Including Apple Juice. (W. B. Esselen, Jr., A. S. Levine, C. R. Fellers, C. C. Strachan.) In view of the increasing interest in bottled and canned

apple juice, further studies have been made on this product. All of the commonly used methods of clarification were compared in order to determine which would give the best-flavored juice. Flash pasteurizing the apple juice at 185° to 190° F. followed by flash cooling with subsequent filtering, using 2½ pounds filter-aid per 100 gallons juice, was definitely superior to the gelatin–tannin and pectinase enzyme methods. The bentonite method was preferable to the latter two methods but inferior to the first-described method from the standpoint of optimum flavor quality.

Flash pasteurization at 175° to 180° F. and filling hot into the containers, followed by sealing and rapid cooling is recommended.

In Massachusetts the McIntosh is the most important commercial apple crop. Unfortunately the juice of the McIntosh has a rather insipid flavor and must be blended with other varieties to make a palatable apple juice. Tests were made to determine the maximum amount of McIntosh juice that could be blended with Baldwin or Delicious juice to yield a satisfactory commercial product. It was found that blends containing up to 60 percent of McIntosh juice yielded a pleasing product. In such blends it is not recommended that over 25 percent Delicious apples be used owing to their strong aromatic flavor.

Apple juice, fresh or canned, contains little vitamin C regardless of the vitamin content of the apple. Fresh apple juice actually destroyed added vitamin C. However, after inactivation of the oxidizing enzymes by heat treatment, the ascorbic acid remained biologically active in the canned or bottled juice. Ascorbic acid is present in apple juice only in the reversibly oxidized form. It is entirely feasible to fortify processed apple juice with crystalline ascorbic acid at the rate of 20 mgm. or more per 100 ml. of juice. The crystals are first dissolved in the deaerated juice which is then flash-pasteurized and canned or bottled without delay. The containers are preferably sealed under vacuum or by displacement with an inert gas such as nitrogen. Juice fortified by this method retains about 90 percent of the added vitamin C after 3 months.

Fruit Jellies and Jams. (A. S. Levine, S. G. Davis, and C. R. Fellers.) The beach plum (*Prunus maritima*) has been used locally for jelly making. Representative samples of the fruits from Cape Cod were collected and some were frozen. Studies are in progress on improved methods of utilizing this fruit in jellies and other products, as well as on composition and nutritive value. Beach plums do not make firm jellies without the addition of pectin, but the added pectin seems to injure the flavor. On the other hand, beach plums make excellent jam without the use of added pectin. The aroma and pleasing astringency are superior to those found in the jelly. It would appear, therefore, that more attention should be centered on the jam and less on the jelly.

The Japanese quince, *Chaenomeles japonica*, a well-known ornamental shrub, produces a considerable quantity of fruits of very pleasing aromatic odor. Attempts were made to utilize these fruits in jelly manufacture. The malic acid content is 5 percent and while considerable pectin is present, the pure jelly lacks character and is excessively acid. Unfortunately, the perfume-like aroma of the fresh fruit is lost in the jelly and in the heat-extracted juice.

Vitamin C Content of Catsup. (W. B. Esselen, Jr., and H. Fran.) A survey has been made to determine the vitamin C content of tomato catsup. Samples for analysis were obtained from the local markets and through the courtesy of several catsup packers. The vitamin C content of nine different brands of catsup varied from 0.05 to 0.12 mgm. per gram or from 28.3 to 68.0 I. U. per ounce. This variation in the vitamin C content of catsup is probably due to its air content, possible copper contamination from equipment, storage temperature, and length of time in storage.

Change in Oxidation-Reduction Potential in Packaged Fruit Juice. (W. B. Esselen, Jr.) A preliminary study has been made on changes in oxidation-reduction potential in canned and bottled fruit juice. In glass-packed orange juice, there was no correlation between the oxidation-reduction potential and flavor changes which took place immediately after packing. The oxidation-reduction potential of apple juice was much lower in plain tin cans than in enamel-lined cans or bottles. Any beneficial effect that the low oxidation-reduction potential of the apple juice in plain tin cans might have in preventing deleterious oxidative changes was offset by an undesirable metallic flavor of the juice.

Glass Container Research. (C. R. Fellers, W. B. Esselen, Jr., W. H. Fitzpatrick, E. L. Moore and J. J. Powers.) Because of the scarcity of tin plate, there has been a marked renewal of interest in glass containers for food packing. Extensive studies have been made on the problems of packing fruits and fruit juices in glass packages. Earlier work on the efficacy of ascorbic acids in preventing discoloration of glass-packed fruits has been confirmed. The use of 1 or 2 one-grain tablets of d-isoascorbic acid or d-glucoascorbic acid in pint or quart jars of canned fruit or vegetables effectively prevented discoloration and off-flavor due to oxidation.

After sealing, commercially packed foods in glass containers lose but little vitamin A and C (*Food Research* 6: 135-141, 1941). Further studies have shown that the total decrease in ascorbic acid is approximately proportional to the enclosed oxygen. Thus, among the important factors influencing ascorbic acid retention are: (1) volume of headspace, (2) degree of vacuum, (3) amount of dissolved and tissue oxygen. Similarly, these same factors may also affect color, flavor, and other characteristics. Modern commercial packaging methods seek to eliminate oxygen from canned foods. This study shows the effect of varying oxygen content on ascorbic acid retention. In fruits and vegetables with high ascorbic acid content (citrus fruits, strawberries, broccoli, etc.), only a small percentage of the ascorbic acid is lost in canning. However, in those initially low in ascorbic acid (pears, peaches, apple juice, plums, carrots, beets, etc.), a substantial percentage, or all, of the ascorbic acid may be lost through reaction with oxygen. Color and flavor of the latter fruits are also adversely affected. High storage temperatures and exposure to light accelerate the ascorbic acid–oxygen reaction in glass-packed foods, but the final total loss of ascorbic acid is unaffected by these factors.

The No. 10 size (105-ounce) glass jar was used experimentally for frozen-packs of strawberries, raspberries, and peaches, packed with and without vacuumization. Results show that vacuum sealing is generally preferable and that this large glass package is very satisfactory for frozen fruits. As in the case of canned fruits, the use of ascorbic acid in small amounts resulted in decreased surface discoloration due to oxidative changes.

Marine Products Research. (C. R. Fellers and J. Lubitz.) Cooperative with Poultry Department. New England poultrymen are constantly searching for new low-cost feeds. Recent developments in canning Atlantic coast crabs have made available considerable quantities of crab meal. This product contains about 34 percent protein, 40 percent ash (mainly calcium), and 2-4 percent fat. The riboflavin content is 3-4 gammas per gram. Pantothenic acid, thiamin, and vitamin K are also present. The meal is an especially good source of calcium, magnesium, iodine, manganese, iron, and copper.

In feeding experiments with rats 85 percent of the nitrogen was available, the balance being present largely as unavailable chitin. Upon hydrolysis chitin yields glucosamine, which proved to be entirely unavailable to rats and chicks

as a source of nitrogen. The biological value of crab protein was approximately the same as that of good grade fish meal. Pigmentation in chicks was slightly increased by feeding crab meal as compared with fish meal. In the New England Conference Chick Starter ration the replacement of fish meal by crab meal on either an equal-weight or equal-protein basis gave results highly complimentary to crab meal. Crab meal sells at considerably lower prices than fish meal; it would seem to be a very satisfactory ingredient of poultry rations.

Dextrose Investigations. (C. R. Fellers, A. S. Levine, and L. Tarkow.) Studies have been concluded on the relative bacteriostatic and mycostatic properties of sucrose, dextrose, and mixtures of the two sugars. Dextrose kills and prevents the growth of bacteria, yeasts, and molds at lower concentrations than does sucrose. That is, dextrose sirups (above 30 per cent) are far less liable to ferment or mold than similar sucrose sirups. The use of dextrose in canned foods, in carbonated beverages, and in soda-fountain crushed fruits and sirups is rapidly increasing. The smaller molecule and the greater osmotic pressure exerted by dextrose in solution are believed to contribute to the greater preserving value of this sugar.

Red Squill Research. (A. S. Levine, C. R. Fellers, and J. Lubitz.) Improved methods for rat extermination are now more important than ever before in reducing the nation's loss by waste.

Red squill was found to be harmless for chickens and rabbits. Guinea pigs are more susceptible than rats to red squill poison. Some popular flavors have been found to be of little value as rat lures. Among these are meat, cheese, anise, caraway, cinnamon, and peppermint flavors. The composition of common baits used as carriers for the squill had little effect on the toxicity of the poison to albino rats.

On account of the war there is now no importation of red squill, and most stocks of red squill still in this country are of low toxicity to rats. Through concentration and subsequent bioassay studies an attempt is being made to increase the toxicity of the present supply.

Three papers have been published on red squill research.

Preservative Values of Organic Acids. (A. S. Levine, R. E. Morse, and M. G. O'Connor.) The addition of small amounts of acetic acid (vinegar) does much to improve the keeping qualities of soda fountain sirups and fruit juices with no impairment of flavors. The addition of only 0.3 percent acetic acid inhibited both yeast and mold growth in strawberry and raspberry sirups. This is especially favorable when compared with the high amounts of citric and lactic acids required for complete inhibition. More than 6 percent citric acid or 5 percent lactic acid was necessary to inhibit yeast growth in these sirups. Four percent lactic acid prevented mold growth but the mold, *Aspergillus niger*, grew in sirups containing over 7 percent citric acid.

Benzoic acid and especially sodium benzoate are still used extensively for the suppression of yeasts in the preservation of fruit juices and sirups. A study is now in progress to determine the effect upon yeasts when definite concentrations of sucrose, dextrose, alcohol, and sodium chloride are used in conjunction with the benzoates. In the preservation of apple juice as much benzoate was required to preserve the clarified as was needed for the unclarified or cloudy juice.

DEPARTMENT OF HORTICULTURE

R. A. Van Meter in Charge

Propagation of Hemlock. (Harold S. Tiffany, Waltham.)

Canadian Hemlock, Tsuga canadensis. Cuttings of one-year wood were taken from hedge trees approximately fifteen years old, in three series at five-week intervals: December 9–14, 1940; January 13–18, and February 17–21, 1941. The rooting medium was one-third peat and two-thirds sand, in open benches under cheesecloth tents and whitewashed glass. Cuttings were kept fairly moist. All treatments were run at constant temperatures of 65°, 70°, and 75° F. (maintained by electric cable), as well as in an unheated bench where the temperature averaged about 60°. Each lot consisted of six cuttings.

Immersion treatments consisted of honey, 25 and 50 percent solutions for 24 hours; indolebutyric acid in the form of Hormodin A, at concentrations of 30, 45, 60, 75, 90 BTI units for 24 hours (with additional treatments at certain temperatures); indolebutyric, indoleacetic, and naphthaleneacetic acids, each at concentrations of 7½, 10, 12½, 15, 20, 30, 40, and 50 mg./100 c. c. water for 24 hours (with additional tests for 16 and 40 hours); Roche 202, at 50, 100, 200 unit solutions for 24 hours. Powder treatments consisted of Formula No. 66 and Hormodin Powders Nos. 2 and 3. An untreated or check lot was included.

Untreated lots rooted little or not at all: at 60° F., 16 percent; at 65°, 33 percent; at 70°, 16 percent; and at 75°, none. Rooted cuttings of successful lots could have been potted at ten to twelve weeks.

Outstandingly rapid rooting, as compared with other treatments, was shown by Hormodin A, 30 BTI units for 24 hours at 75° F. This reaction checked similar findings of the previous season (Hormodin A, 45 BTI units for 24 hours). See photograph page 56.

Cuttings from Series I, taken in early December, gave much higher percentages of rooting than those of Series II or III. In the previous year mid-December cuttings did not root as successfully as those taken in mid-January. This variability can be at least partially explained by the early low temperature and snow fall of November 1940 which brought the cuttings to a condition for satisfactory rooting much earlier than was the case in the preceding year when such conditions did not materialize until January.

Of the thirty-one treatments which gave 100 percent rooting, the most consistently successful was indolebutyric acid 7½ mg./100 c. c. for 24 hours. The finest normal root systems were developed with this treatment at 65° F. (see photograph, page 56), with good rooting at 70° and 60°. Of economic significance is the fact that this treatment gave 83 percent good rooting in the unheated bench at an average temperature of 60° (widest fluctuations in the bench temperature were 57° and 63°). Consistency of the treatment at 65° is further shown by 100 percent rooting from 7½ mg. upward through 40 mg., although as the concentration increased the roots were shorter and some injury was apparent.

Hormodin A trials were consistently good with percentages of 100 on half the lots. Best-developed root systems were from 90 BTI units, 24 hours at 65° F. As would be expected, lower concentrations did best at higher temperatures and vice versa. This was shown particularly well by the best 100 percent rootings in the Hormodin A, 24-hour trials: 30 BTI at 75°, 60 BTI at 70°, 90 BTI at 65° and 60° F.

Cuttings treated with indoleacetic acid gave 100 percent rooting at 60° and 65° F. with concentrations up to 10 mg./100 c. c. In no instance did the condition of the roots excel or equal the condition of those treated with indolebutyric acid.

All naphthaleneacetic acid treatments gave indication of injury by basal burn

and proliferation of roots. Roche 202 treatments gave variable results—from 0 to 100 percent rooting. As in the case of most treatments, best rooting was at 65° F.

Hormodin Powder No. 2 brought 83 percent rooting at 70° F., but fell to 66 percent at 65°. Hormodin Powder No. 3 gave best rooting at 65°—100 percent. Root development with powder treatments was much inferior to that produced by immersion treatments of indolebutyric acid. The results with Hormodin Powder No. 3 were generally paralleled by Formula No. 66.

Tsuga canadensis vars. *pendula* and *minima*. Results of treatments suggest these varieties propagate readily. The records approximately parallel those for *T. canadensis*.

Tsuga canadensis var. *Beaujean*. Preliminary tests of twelve lots suggest that this variety does not propagate so readily as those mentioned above.

Generally, indolebutyric acid has shown definitely superior results to other treatments in these trials and at low concentrations. A constant temperaure of 65° F. appears optimum throughout the trials, with the exception of Hormodin A at 30 BTI at 75°. Cuttings rooted best when taken soon after the first protracted cold weather of the season.

Tests will be continued in 1941–42 with indolebutyric acid in various forms at minimum concentrations and optimum temperatures.

Propagation of Mountain Laurel. (Harold S. Tiffany, Waltham.) Preliminary trials in 1940 gave indication of a low percentage of rooting from hardwood cuttings of mountain laurel, *Kalmia latifolia*, taken in mid-January. Treatment with indolebutyric acid in the form of Hormodin A at 60 BTI units for 16 hours gave 20 percent rooting, while fairly high concentration of the salts gave only 10 percent. These roots developed in a sand medium; no roots developed in a medium half sand and half peat, or in peat alone.

Since successful propagation of the best white and deepest pink variations of mountain laurel would be of decided value, a program of winter propagation trials was carried out during 1940–41. Three series of cuttings were taken: December 19–26, 1940; January 30–February 6 and March 13–20, 1941. Thirty-eight treatments (plus other varied trials) in lots of six cuttings each for each series were duplicated at constant temperatures of 65°, 70°, and 75° F., and in an unheated bed averaging 60°. These were as follows: honey, 25 and 50 percent solutions; Formula No. 66 and Hormodin No. 3; Hormodin A at 45, 60, 75, 90, 120, 150 BTI solutions; indolebutyric, indoleacetic, naphthaleneacetic acid salt solutions at concentrations of 10 mg./100 c. c. through 80 mg./100 c. c. (10 unit progression); Roche 202 at unit strengths of 50, 100, 200, 300; and an untreated lot.

While rooting percentages of the previous season's tests were perhaps slightly bettered (33 percent), it appears from these results that the propagation of mountain laurel from hardwood cuttings may not be feasible.

The twenty-eight plants rooted did not continue root development after transfer to pots, seeming to hold only growth that had been made in the rooting medium. The cuttings rooted in 1940 also exhibit an equal lack of normal vitality.

Propagation of Lilac. (Harold S. Tiffany, Waltham.) The time of taking cuttings of the common lilac, *Syringa vulgaris* var. *Andenken an Ludwig Spaeth*, has been varied from May 28 to July 1. In no instance have rooting percentages been as high as for those taken in late May at the time the flowers are about half way into bloom. At this time the new growth is about 6 to 8 inches long, making for good-sized plants when rooted. Rooting percentages of the 1200 cuttings taken for test June 10, 1941, about two weeks after the optimum time, fell off

from 30 to 40 percent. Optimum temperature of the medium, one-third peat and two-thirds sand, was found to be about 70° F. Hormodin A, 40 BTI units for 24 hours, and Formula No. 66 each gave 95 percent good normal rooting.

Propagation of Juniperus virginiana var. glauca. (Harold S. Tiffany, Waltham.) Several varietal forms of *Juniperus virginiana* are propagated commercially by grafting to understocks of this species, since no satisfactory percentage of rooting has been obtained from cuttings. The variety *glauca* is one of these.

Preliminary trials in 1940 of wood of the current season and of two-year wood gave high rooting percentages on the one-year wood and very low percentages of rooting on the two-year wood. Both sand and half sand, half peat appeared satisfactory media, although cuttings in the sand–peat rooted satisfactorily in 11 weeks, while those in the sand consistently required 14 weeks.

A series of cuttings, twenty to each treatment, taken in late January 1941, were put in sand–peat in open unheated benches at a temperature averaging 62°. Thirty-four treatments with root-inducing substances were made for 16, 24, and 40 hour immersions.

Indications show successful rooting confined to indolebutyric acid treatments with a range of rooting percentages up to 100. Untreated cuttings gave no indication of rooting. A higher temperature of the rooting medium appears to be necessary for best results.

Factors Increasing the Rapidity of Growth of Nursery Stock. (Harold S. Tiffany, Waltham.) To determine best cultural practices for rapid quality growth of lining out stock, plots of various plant materials have been laid out from 1939 through 1941. These include plantings of *Tsuga caroliniana* and *canadensis*, *Thuja occidentalis* var. *globosa*, and *Syringa vulgaris* var. *Souvenir de Ludwig Spaeth*.

A series of fertilizer treatments was applied in duplicate, in 1940 and 1941, to fourteen plots of *Tsuga caroliniana*. Treatments were based on 5-8-7 (one third ton per acre) as a balanced fertilizer adequate in amount for the needs of young evergreen trees. One-half the nitrogen was supplied by nitrate of soda and one-half by sulfate of ammonia. Phosphorus was supplied by superphosphate, and potash by muriate of potash. Manure and peat moss represent two other treatments.

Growth measurements in inches for each of the years 1940 and 1941 were secured from plots treated with manure (15 cords per acre) and peat moss (annual application of 2 inches hoed into the soil).

While other treatments also show measurements exceeding those of the untreated plots, further results are needed before conclusions can be drawn.

Study of Herbaceous Perennial Material. (Harold S. Tiffany, Waltham.) Records of the 1941 season have been included with material previously obtained, giving the average time and duration of bloom, height, and color of the better and enduring garden perennials. Averages for a period of five years are now available for most of the plants.

Additions to the peony collection, chosen as representative of the best of their types from a study made by the University of Illinois and the American Peony Society, are as follows: Single—Catherine Parry, Departing Sun, Harriet Olney, Le Jour, Marguerite Dessert, Mellin Knight, Mischief, Shirley Walker; Japanese—Antwerpen, Cathedral, Fuyajo, Hakodate, Kukenu-Jishi, Margaret Atwood, Mikado, Some-ganoko, Surugu.

Hardiness Trials of Clematis Varieties. (Harold S. Tiffany, Waltham.) A limited number of three-year plants was set in the nursery, from pots, in the

spring of 1940 and given a severe test the following winter without the benefit of winter protection.

The only 100 percent survivors after a winter during which a lasting blanket of snow offered good protection, were the varieties Mme. Edouard Andre, Elsa Spath, and Duchess of Edinburgh. Over 75 percent of *Comtesse de Bouchaud* lived; 66 percent of *Henryi*; and 50 percent of *Romona* and *montana* var. *rubens*. The species *ascotiensis*, *crispa*, *tangutica* var. *obtusiuscula*, and the varieties Belle of Woking, Gipsy Queen, Mrs. Cholmondeley, Nelly Moser, Ville de Lyon, and Ville de Paris were entirely winterkilled.

While the number of plants was insufficient for a thorough test, and although the test represents but a single winter, the hardiness of the plants of Mme. Edouard Andre, Elsa Spath, and Duchess of Edinburgh is promising.

Powdery Mildew on Garden Phlox. (Harold S. Tiffany, Waltham.) A spray control program of Bordeaux mixture 1-1-50, Hammond's Copper Solution 1-150, Basi-Cop 1-50, and Wettable Sulfur 2½-50 was applied to plantings of *Phlox paniculata* from May to the time of flowering. Applications were made at intervals of 7 to 10 days.

Hammond's Copper Solution, with no residue, was again superior in both control and appearance to Bordeaux Mixture, which left some residue on the plants. Wettable sulfur gave better results than did Basi-Cop.

Factors Influencing the Hardiness of Evergreens. (Harold S. Tiffany, Waltham.) Records of terminal growth averages on *Taxus baccata repandens* after the first season of cultural treatments showed a definite correlation of growth with treatment. Sod with no cultivation afforded fairly normal growth, yet the plants lost much of this growth by the next spring. Cultivation with no fertilizer gave a normal amount of growth, and these plants suffered least from winter injury. The spring application of nitrate of soda at the rate of 300 pounds per acre gave the most growth, yet the plants were not injured comparably. As expected, greatest winter injury came from manure, 15 tons per acre applied in May and in August.

Winter injury is calculated by (a) the number of terminals entirely winterkilled, (b) terminals killed approximately two inches from tip down, (c) tip injury to the bud with approximately ten needles killed, and (d) number of retarded terminals after growth has started. After trying several methods of measuring winter injury, this means appears to hold fairly constant.

In 1941 additional fertilizer was given with the late August application of manure for still further contrasts. A cover crop of annual rye grass was planted in August on the nitrate of soda plot to check growth early and encourage hardening after a rapid early growth.

The dry 1941 season consistently lessened growth averages by approximately 25 percent. An exception to this was plants of *Taxus canadensis stricta*, which showed more average growth than in the previous season in all plots. Explanation may be that the plants had not become fully established at the end of the first season of treatments, or that they withstand drought better than either *Taxus baccata repandens* or *Taxus cuspidata*.

Propagation of Mugho Pine. (Harold S. Tiffany, Waltham.) A series of cuttings of Mugho pine, *Pinus mugo* var. *Mughus*, was given preliminary tests in 1939-40, and the work for 1941 was based on the results of these tests.

Lots of five cuttings each of one-year wood taken in January were placed in open benches, in a rooting medium of one-third peat and two-thirds sand, with temperatures averaging 65° and 62° F. Dip treatments consisted of Formula No. 66 and Hormodin No. 3; immersion treatments, of honey 25 and 50 percent

solutions, Hormodin A at 30, 45, 60, 75 BTI units, indolebutyric, indoleacetic, and naphthaleneacetic acids at concentrations of 10, 15, 20, 25, 30, 35, 40, 45, 50, and 60 mg./100 c. c., Roche No. 202 at unit concentrations of 25, 50, 75, 100, 125, 150, 175, 200; and an untreated lot. Each immersion treatment was continued for 16, 24, and 40 hours.

A series of fifteen cuttings to the lot was taken in February and run in sand and sand-peat at a constant temperature of 65° F. Treatments were Hormodin A at 90, 105, and 120 BTI units, with additional test treatments of indolebutyric acid. Results were slightly better from the sand-peat medium than from the sand, and from a higher temperature of the rooting medium. Highest rooting percentage was 80 with indolebutyric acid at 40 mg./100 c. c. for 24 hours at 65° F. in sand-peat. Immersion treatments for 24 hours with Hormodin A at 90 BTI units (in sand) and at 120 BTI units (in sand-peat) gave 66 percent rooting; and at 90 BTI units (in sand-peat) 65 percent rooting at 60° F. In the untreated lots a single 13 percent rooting occurred at 65° F. in the sand-peat medium. Rooting from other lots was negligible.

DEPARTMENT OF OLERICULTURE

Grant B. Snyder in Charge

Variety Studies. (W. H. Lachman and G. B. Snyder.) These studies are conducted each year to ascertain the adaptability and general usefulness of the newer introductions in comparison with the standard vegetable varieties. The weather conditions at Amherst during the summer of 1941 were very near to the average for the last 50 years and were ideal for proper growth and development.

Especially noteworthy was the new "Summer Pascal" celery which produced a medium large plant weighing a little over two pounds and measuring about 20 inches in height. This variety produced a crisp, succulent stalk with an excellent nutlike flavor.

There were 62 strains and varieties of tomatoes included in the trials. Particularly outstanding were "Stokesdale," an early mid-season variety which yielded well and had good shape and size, and "Rutgers," a late, high-yielding, very attractive tomato which is especially valuable for canning. The varieties "Victor" and "Bounty" which are early varieties proved a little disappointing because of poor fruit color and sparseness of foliage. "Pan American," a new introduction of the U. S. D. A., is reported to be highly resistant to fusarium wilt. This variety has excellent foliage, but from the experience gained by limited trial, large plantings are not suggested because of only a moderate yield and variable fruit shape and size when grown either pruned and trained or unpruned and untrained.

During the summer, eight varieties of tomatoes were tested for vitamin C, with the following results:

Variety and Source	Ascorbic Acid (mg. per gram of tomato)
Bounty—N. D. Agr. Expt. Sta.	.15
Early Rutgers—N. J. Agr. Expt. Sta.	.20
Gradwell—Scott	.21
Marglobe—Landreth	.17
Ohio Red—Ohio Agr. Expt. Sta.	.16
Pan American—U. S. Dept. Agr.	.21
Victor—Harris	.17
Waltham Forcing—Waltham Field Station	.23

Also important among the newer vegetables was the "Yankee Hybrid" summer squash. This variety is from three to seven days earlier than standard varieties. It has a straight neck, good quality, uniformity, and gives an exceptionally high yield over a long season. The "Delicious" and "Golden Delicious" varieties of winter squash were outstanding in quality and store moderately well.

Shape Index Studies of Tomatoes. (W. H. Lachman.) Five years ago a quantity of seed was obtained of eight varieties of tomatoes that displayed major differences in the shape of their fruits. Each year small plantings have been made from the original stocks of seed to determine the effect of the various weather conditions in modifying the shape of tomato fruits. While considerable data have been collected, it is felt that more information is necessary before the results are summarized.

Tomato Breeding. (W. H. Lachman and G. B. Snyder.) The tomato breeding project has been confined to the problem of incorporating the uniform ripening gene into otherwise desirable tomato varieties. The uniform ripening character is inherited in a simple manner and is dependent upon one pair of genes for its expression. During the past season an F_2 population of 293 individuals was grown and the ratio was 3.37 normal green-shouldered individuals to one of the uniform ripening. The uniform character appears to be a recessive, and these results agree with the work of other investigators.

Many single plant lines have been established, some of which are in the F_6 generation. The main difficulty has been to obtain lines which have sufficient foliage to provide an ample coverage for the fruits and thus prevent sunburning. Many of the original lines were determinate in habit of growth; that is, the main stem grew for a short distance and then was terminated by a blossom cluster. Any subsequent growth was made by lateral branches.

Most of the more recent selections made have been indeterminate in habit and thus the coverage of foliage is much better. Also, this type of plant can be pruned and trained to a much greater degree of satisfaction. It is planned to multiply the seed of the three best lines so that they can be sent out for trial among a number of vegetable growers.

Sweet Corn Breeding. (W. H. Lachman.) The object of the corn breeding program has been to develop a hybrid which would provide earliness, productivity, disease resistance, and quality. During the past five years a system of inbreeding has been practiced in an effort to obtain superior inbred lines with characteristics which are sought in the hybrid. Approximately 100 such inbred lines have been obtained and the work now consists of testing the inbreds in various combinations of crosses to ascertain which of the combinations are most desirable.

During the past summer 40 such combinations were planted and carefully studied during the growing period. Five of these performed especially well and have been recommended for further trial. If they grow and produce as well in another season, the seed stock will be multiplied and sent out for trial among a number of vegetable growers. More combinations of the inbreds have been made and will be tested further.

Hybrid Sweet Corn Trials. (W. H. Lachman.) Hybrid corn has taken the country by storm. Many varieties have been introduced lately and the list grows longer each year. It has been recognized, however, that each hybrid has a narrow range of adaptability because they are susceptible to very small changes in environment. Hence, regional tests must be made before any hybrid can be recommended for production within very narrow limits or localities.

Therefore, tests are conducted each year, particularly of the yellow varieties, to observe earliness, yield, quality, disease resistance, and general adaptability for this locality. Of the hybrids that have been tested for the past three years four are especially noteworthy.

Spancross (C4×C13) is an extra early, very productive hybrid, and matures in about 70 days. It has good quality, is very uniform and has a medium-sized ear measuring about 6¼ inches in length. This variety is two or three days earlier than Golden Early Market.

Marcross (C6×C13) has a large ear, about eight inches long and is an early-maturing variety. It is only four or five days later than Spancross but not quite so good in quality.

Marcross (P39×C13) also known as Carmelcross is a mid-season variety which matures in 80 to 82 days. This variety produces a large ear and has excellent quality and appearance.

Golden Cross Bantam is a late market corn which matures in 85 to 89 days. It produces a good crop of cylindrical, well-filled ears that are of exceptionally fine quality. This variety is highly recommended.

The Effects of Mulching Tomatoes and Peppers. (W. H. Lachman and G. B. Snyder.) Each season soil moisture becomes one of the most limiting factors in the production of vegetable crop plants. Any treatment or practice which will aid in conserving soil moisture for plant use during critical periods becomes especially significant to the vegetable grower.

Various mulches have been applied to the soil and compared with clean cultivation in the culture of tomatoes and peppers. Straw, banana fibre, and horse manure were the materials used. Based on the results of the tests for two years, it is doubtful whether mulches have a significant influence on yield, cracking, or quality of the fruit.

If mulching was continued for several years it is conceivable that the increase in organic matter might exert a more marked influence on growth and production. The applications of banana fiber changed the soil pH from 5.7 to 7.0, but this change was not reflected in the growth of the plants.

Samples of soil were taken from each of the plots and chemical analyses made by Philip H. Smith of the Control Service. The results show that the various treatments had a rather insignificant influence upon the mineral content of the soil. The soil under the banana fiber mulch is considerably higher in potassium, but other differences are either lacking or not significant.

Cucumber Seed Treatment. (O. C. Boyd and W. H. Lachman.) Samples of pickling cucumber seed were obtained and treated to control seed-borne diseases as well as diseases caused by soil-inhabitating organisms. Dusting the seeds with red copper oxide, whether they had been previously soaked in mercuric chloride solution or not, just doubled the stand of seedlings. The principal benefit of this treatment was the prevention of seed decay and pre-emergence damping-off, rather than the prevention of post-emergence damping-off. There was no evidence of injury to germination by any of the treatments.

Sources of Organic Matter for Greenhouse Tomatoes. (W. H. Lachman and G. B. Snyder.) The scarcity of animal manures as a soil amendment has led to a search for substitute materials. The main object was to find a cheap material which would provide a good source of organic matter and support the growth of greenhouse tomatoes. Straw and peat moss were the two materials best suited for the problem. Straw has proved to be the better of the two materials and is more economical. Both materials, however, must be supplemented with sufficient commercial fertilizer to compensate for the nutrients supplied in manure.

Tri-State Cooperative Vegetable Variety Project. (G. B. Snyder and W. H. Lachman.) This project is conducted in cooperation with the Rhode Island and Connecticut Experiment Stations. The object is to ascertain the influence of the various climatic and edaphic factors upon several strains of beans, sweet corn, peppers, cabbage, celery, tomatoes, and carrots. The data for four years are now being summarized.

Bean Culture. (W. H. Lachman and G. B. Snyder.) One of the limiting factors in the culture of lima beans has been the sparse stand of plants obtained because of poor germination. A rather comprehensive test was made of the value of "Spergon," a commercial preparation used as a dust on the seed. The seed treatment increased the germination about 25 percent and the treated plants were more robust and healthy than the untreated lots.

A number of varieties of edible soy beans have been tested for two years. The varieties "Giant Green" and "Willomi" performed especially well and have a very pleasing flavor. One of the reasons why the public has hesitated to accept soy beans as a vegetable is because they are so difficult to shell. It has been found that the beans shell very easily if they are first boiled for about three minutes. The beans can then be cooked and served much the same as lima beans.

Asparagus Investigations. (Robert E. Young, Waltham.) The yields of 450 plants in five different lines derived from previous selections were in a somewhat different order from those of last year. The yields did not increase as would be expected for asparagus plants that have been cut only two full cutting seasons. The strain that produced the greatest yield last year was second in 1941.

Although the production of the best strain was about double that of the poorest strain and of plants from commercial seed growing alongside, the results of these individual cutting records show that there is a wide variation in the performance of the plants of even the best strain. That the yield can be doubled in one generation establishes great possibilities in asparagus breeding.

Increasing the yield gave a slight increase in the percentage of extra large stalks, and a slight increase in the average weight. In checking the performance of the 25 highest yielding plants it was found that there was a great variation in the type of spears produced. Some plants produced very few large spears but many small ones, while others giving as much in total yield produced mostly large-sized stalks, although when the strains were taken as a whole this difference did not show to any great extent. In the best strain 24 percent of the plants produced a bunch of asparagus (1.25 pounds), while in the commercial strain only 2.5 percent produced as much.

At the time of the fall stalk count, quite a number of plants had rust in varying degrees of severity, including the commercial line of Mary Washington, supposedly rust resistant. The percentage of rust present in the selected strains in the order of their yield was 14.2, 17.0, 13.0, 5.0, 3.3, compared to 39.7 percent for the commercial strain. This would indicate that progress can be made in obtaining not only better yield but also better resistance to the rust disease.

The various characteristics of yield, size, bud shape, height of branching, spreading of tips, and color are so variable that new selections will be made next year to secure more uniformity.

Vegetable Breeding for Improvement of Quality. (Robert E. Young, Waltham.)

Trellis Tomato. The program of developing better internal and external fruit quality in our two strains of trellis tomatoes has been continued. For reasons not wholly understood, the yield of the 1941 tomato crop was only about 50 percent of last year's although the plants set and the care given were better. Poor tomato crops were reported all along the eastern seaboard. The dry weather, no doubt,

had its effect, but our plants were irrigated and did not suffer for water. The earliness was not affected but there was a general lack of vigor and insufficient foliage.

A number of hybrids were made in the greenhouse last year in order to introduce certain characters of quality, also to test other varieties as to their value in combining with our strain to produce a satisfactory hybrid. One of the varieties used was Victor, a new determinate type, early, with uniform ripening of the fruit. At that time it was thought that the uniform ripening character was a desirable one for our strains. The hybrids of this cross did not have the usual vigor of the other tomato hybrids. The stems were weak and small. Insufficient replicates were grown to make possible an accurate determination of yield but the yield of early fruit was not so heavy as would be expected. During the season observations were made of the way the fruit of the Victor, and other varieties having uniform ripening character, colored and there is now a question whether this character is desirable in our trellis types. A cross between Trellis No. 22 and a late, vigorous Comet was much later than would be expected. This cross was made to obtain more foliage for a tomato of the No. 22 type.

From the behavior of these and other hybrids, it would seem that our trellis type tomatoes exert very little effect on the hybrids in which they are used.

It has recently been reported that the hybrid vigor of summer squash exhibited in the F_1 generation was carried over into the F_2 population. This F_2 lot of plants, while showing segregation as to size and shape, still had earliness and yield. If this fact should be true for tomatoes, it would be easy to produce the F_2 population from a few hand-pollinated hybrid fruits. To determine whether tomatoes will behave in this way several plots were grown of the parents F_1 and F_2 of Waltham Forcing $\times$ Early Rutgers. The poor crop made it difficult to evaluate the results but it would seem that the F_2 of this hybrid was about as good in production as the F_1. Further study will be made of this factor and a rating of the desirability of other varieties as parents in such a program.

During winter meetings with the growers the question has been asked as to the value of using early started tomato plants. Certain growers felt that an older plant will produce earlier. To test this contention seed of the Waltham Forcing tomato was sown on February 15. The plants were carried along slowly and transplanted several times, but at setting time they were really overgrown. They were not potted but dug out of the bed with a ball of soil. These plants had ¾-inch fruits at setting time. The regular crop was started April 1 and transplanted in a bed in the greenhouse 2×2 inches, then to the coldframe 4×4 inches. These plants also were set with a ball of soil. It is true that the early started plants had ripe fruits very early, but they were small; during the first three pickings they produced an average of 8.5 fruits that weighed .92 pound per plant, compared to 11.3 fruits weighing 1.6 pound per plant obtained fron the regular crop. The total yield from the early started plants was 1.95 pounds compared to 2.69 pounds from the plants started at the regular time, and from these results it would seem that if plants are to be started early they must be grown in pots or baskets. These plants were very slow to start growth after setting.

Greenhouse Tomatoes. During the year trials of various hybrid tomatoes have been made to see which will combine with the Waltham Forcing and Bay State to produce a good tomato with hybrid vigor. An F_2 generation of a cross between Waltham Forcing and Michigan State Forcing was also grown, and the results indicate that the F_2 plants are vigorous. The yield was very high although the fruit was not very uniform.

A discovery that may make the production of hybrid seed much easier is that the tall non-productive plants that have frequently been found in the Waltham Forcing strain in the greenhouse are only partially sterile. Pollen from good

plants will cause the sterile plants to set seed. If these plants can be used, there will be no need of emasculating the flower to obtain hybrid seed.

Summer Pascal Celery. This year 20 different single-plant selections of Summer Pascal celery were tested to determine whether a longer petioled strain could be obtained; and no irrigation was supplied after the paper for bleaching was applied, in order to determine whether there were differences in the susceptibility to heartburn. Some of the single-plant selections showed almost 100 percent heartburn, while the best had only 25 percent. This severe heartburn provided an opportunity to make selections that did not heartburn for the supply of stock seed.

The results of trials in past years have shown that seed from selected celery plants grown in the fall cannot be raised in time for the next year's crop. Experimental work with light and heat has not hastened the seed stalk development to any extent. A crop of seed was raised outside to provide ample supply of stock seed for our growers. The demand for Summer Pascal celery is greatly increasing.

Greenhouse Lettuce. The third generation of a cross between Bel-May and an English variety, Cheshunt Giant, was grown at the Waltham Field Station and in two growers' houses. Selections were made and seed produced of the most promising. The hybrids have darker green color and better overlapping of leaves on the bottom, and are slower bolting to seed. It will require another generation or so to completely remove the off-type plants from the strain.

Rutabaga or Cape Turnip. A good crop of turnips was produced on the Field Station grounds. As a result three distinct types have been selected, and sufficient seed will be grown to enable the growers to try them on their own farms. Type No. 1 has white flesh with white or light green shoulder, and the root is almost uniformly colored from top to bottom. Type No. 2 has white flesh with a slight purple shoulder. Type No. 3 has yellow flesh but is otherwise of the same character as Type No. 2. Most yellow-fleshed turnips have a dark purple shoulder.

The type of soil at the Field Station is such that a good turnip crop is not assured each year and if further work is needed it should be done in the turnip sections such as Bristol County.

Wyman Crosby Beet. There seems to be a definite correlation between speed of growth and color in beets. The larger roots of the Wyman Crosby strain of beet always seem to be of poor color, while the small roots are usually a dark red color. Twenty-five different selections of single and mass roots were grown and several proved to be very uniform and somewhat of a compromise in that they were of dark color and medium speed of growth. It will require time to build up sufficient seed to try these out on a large scale.

Greenhouse Cucumbers. About 30 different strains and varieties were grown for self-pollination in the field. Some of the strains are approaching sufficient uniformity to permit the hybridization program to be undertaken. Some experimental hybrids tried during the year have been outstanding in yield. The past year's crops have shown that there is a large difference in the vigor of the various lots under trial. Only about 40 percent of the self-pollinated blossoms set fruit, and further study will be made of the methods of pollination and also the effect of homozygous conditions of fruit setting.

Green Sprouting Broccoli. Both the spring and fall crop have afforded an opportunity to make selections of the crosses made during the winter in the greenhouse. Crosses were made between several quite widely different types. The

F_1 generation has shown that there is a large difference in uniformity between hybrids made between homozygous parents and crosses in which one or both parents were from commercial strains. It will require considerably more testing before the real value of any of the lines can be determined.

Hutchinson Carrot. The F_4 generation of a cross of Hutchinson × a Turkish red carrot was grown during the fall. While many of the other vegetable crops this season were poor, the carrot crop was the best in years. The hybrid material was so promising that several lines will be increased for further testing on a larger scale. These new lines have a very uniformly colored root and have a pleasing external color much darker than the Hutchinson.

The stock seed crop of Hutchinson carrot was very small. The plants blossomed profusely but only a small percentage of the flowers set seed. It is probable that the dry weather was not conducive to proper fertilization. To meet the demand for this seed from the seedsmen, a large crop of roots was grown and placed in storage for next year's crop.

Lettuce, New York Type. Three crops of lettuce grown during the season have shown that the strain of lettuce which, because of past performance, was thought to be the most satisfactory will not stand during hot weather without bolting to seed. The early crop, in which plants are set, was small but satisfactory. Comparisons were made, and the better selections showed up well. The first crop in which the seed was planted directly in the field, and which matured in early July, indicated that the best selections definitely had resistance to tip burn.

In this planting was some of a newer selection about ready for release by the U. S. Department of Agriculture which showed excellent heading characteristic, but was small and so crisp as to make it questionable whether it would stand handling in the market. The characters this lettuce has will be combined with our bigger strain resistant to tip burn, which should combine all the desirable characters needed to make a good lettuce for Massachusetts. The fall crop of lettuce confirmed the results obtained in the summer crop.

Samples of the best selections now on hand will be given to a few growers for trial next year.

DEPARTMENT OF POMOLOGY

R. A. Van Meter in Charge

The past season was in strong contrast to that of 1940 in many respects. It opened early and fruit trees bloomed earlier than in any other of the past twenty years. Rainfall was very deficient in the spring of 1941, normal or above in June and July, and low for the last of the summer. Rainfall was heavy in the spring of 1940 and light in the fall, while fruit bloom was late. The rainfall for the summer of 1941 was less than three fourths of the normal amount in Amherst and still less in some parts of the State. Yet tree growth was good at Amherst and apples grew to normal size. The explanation may be largely in the good rainfall for June and July. Trees came through the spring drouth on reserve water from the winter. Soil water drained away early, admitting air to the soil and favoring early root activity and later leaf development. Summer rainfall was enough to maintain growth. Dry weather in the spring is favorable to fruit trees provided it does not continue too long.

Peach fruit buds survived the winter and a good crop was produced. Raspberry canes winterkilled badly, with a consequent reduction of the crop.

The Influence of Various Clonal Rootstocks on Apple Varieties. (J. K. Shaw and L. Southwick.) The new stock bed set last year made a good growth and should yield several thousand rooted layers in 1942. Several new stocks from the United States Department of Agriculture were added. No layers were taken from this bed this year but the old bed yielded a crop of layers that were lined out for budding. Layers from the more vigorous stocks can always be budded the first season but the dwarfing stocks require good growing conditions if they are to be suitable for budding in their first year.

The cooperative clonal stock orchards are as reported last year. Some are doing well and should contribute to our knowledge of the interrelations of these stocks with our American varieties; others are failures. One orchard that did very poorly for the first three years has improved greatly in the last two years. It is on a shallow soil with a high water table in the spring. During the past two years it has been cultivated with a crop of string beans. The reason for marked improvement may be that aeration of the soil has improved conditions for root activity. An additional cooperative orchard of over 1000 trees on these clonal stocks will be planted next spring.

All the trees in our own five-year-old orchard continue to grow about alike. They have been in cultivation and have borne few apples, yet they are now large enough to bear a bushel or more each. The orchard will soon be seeded to grass which should bring the trees into bearing promptly and show whether the trees on the various stocks react differently. Two trees of Red Spy on the very dwarfing Malling IX, one with several apples, broke off, emphasizing the fact that trees on this stock should have support.

The McIntosh orchard planted in 1928 grew better than last year. Comments on the mulched areas are made in the report on the Mulching Project. As measured by trunk diameter, McIntosh trees on Malling XII, XV, and XVI and on their own roots are now larger than the trees on seedling roots; trees on Malling X and XIII are somewhat smaller; and trees on Malling I, V, and VI considerably smaller. Trees on Malling IV are almost as large in trunk diameter and spread of top as those on seedling roots but are not as tall, indicating that this is a promising stock for fruit growers who wish to avoid tall trees.

The trees on various stocks in the 1939 orchard continue to grow about the same; little indication of dwarfing effect of the stocks has yet appeared. A few scattered trees bore apples. In midsummer leaf scorch and partial defoliation appeared. The symptoms suggested magnesium deficiency and an analysis of leaf samples supported this. The trees were given a liberal application of potash (with nitrogen) in the spring of 1941 and it has been shown that potash applications bring out symptoms of magnesium shortage. The situation will be studied further and steps taken to remedy it.

The diameter of the bulge or swell at the point of union and that above and below the union were measured in June. The diameter above the union always averaged smallest. The swell was larger with the stocks known to be dwarfing, and was influenced also by the scion variety. It is doubtful whether the size of the swell is of much significance in the performance of the trees. This work will be more fully reported elsewhere.

Lethal Incompatibilities between Clonal Stocks and Varieties of Apples. (J. K. Shaw and L. Southwick.) The above project is concerned with stock–scion combinations that may be useful in orcharding. There have appeared some combinations that fail sooner or later. We have been unable to make some of the flowering crabs grow on some of these clonal stocks. Cases are known in which comestible varieties fail. Deeming this situation worthy of study, a new project has been started in an effort to learn the reason for such failures.

Tree Characters of Fruit Varieties. (J. K. Shaw, A. P. French, O. C. Roberts, and L. Southwick.) This project has been carried on for many years. As new varieties are constantly appearing there seems to be no end in sight of a need for such work. Varieties of apple, pear, plum, cherry, and peach desired for observation are maintained in the nursery. The usual inspection of nurseries for trueness to name was made, but certification under the auspices of the Massachusetts Fruit Growers' Association was discontinued this year. If trees are kept true to name in the nursery row, the chances of a grower getting trees not true to name is small; and it was felt that the relatively expensive certification was not worth while.

The Genetic Composition of Peaches. (J. S. Bailey and A. P. French.) Special attention was given to the inheritance of blossom characters. Results indicate that blossom type (showy or nonshowy blossoms) is controlled by one pair of genes (Shsh), with the nonshowy type dominant, and that blossom size is controlled by one or more other pairs of genes. This work will be reported in the *Proceedings of the American Society for Horticultural Science.*

Comparison of Cultivation and Sod in a Bearing Orchard. (J. K. Shaw.) This project was continued as in the past but a new project referred to elsewhere was started on one of the complete-fertilizer plots. Another plot is used for the mulching experiment and is referred to under that project. The remaining five plots continue to indicate that on this soil a balanced fertilizer is now necessary. It suggests that the fruit grower who is using nitrogen alone as a fertilizer should watch for indications of a shortage of other elements. As long as nitrogen alone results in satisfactory performance of the trees it should be continued, but any symptoms of shortage should be promptly diagnosed and the deficiency supplied.

Comparison of Cultivation and Heavy Mulching for Apples. (J. K. Shaw.) The two small plots where heavy mulching was begun in 1922 continue as reported last year. The mulch material decays rather slowly and bids fair to last several years without additional applications. The trees continue to grow and bear well although grass grows vigorously up through the mulch.

Additional mulch was applied to plot 3 in the cultivation–sod orchard. The material was weighed this year. It amounted to 4225 pounds applied to 10 trees or about 5½ tons per acre. Probably this amount applied annually is more than is economical. Rootlets are much more abundant just beneath the mulch than in surface areas under cultivation or sod. Doubtless there are three conditions that would favor such root development: (a) better and more uniform moisture supply, (b) more readily available nutrients, and (c) better aeration. The growth on these trees this summer was remarkably good and the crop was the largest of any of the seven plots in the orchard. When the mulching was begun four years ago nitrogen must have been very low and the cover crop was negligible. The mulch was applied to almost bare soil. Yet there never have been any signs of nitrogen depression following these liberal applications of waste hay. The trees immediately improved in vigor and production and continued to do so in successive years. No fertilizer, other than the mulch, has been applied for twenty years.

The two plots in the McIntosh clonal stock orchard received additional mulch this second year. The material weighed 13,300 pounds or about 6½ tons per acre. This again is an excessive amount and will be reduced in the future to see if equally satisfactory results can be obtained. The rest of the orchard was seeded in August 1940, to a mixture of red, alsike, and Ladino clovers. A good stand was obtained and now consists mostly of Ladino clover. The clover areas (about two acres) were fertilized with 150 pounds nitrate of soda and 200 pounds nitrate of

potash with an additional 2 pounds nitrate of soda per tree applied under each tree, no clover growing there. The mulched trees received no other fertilizer. The two lots of trees look about the same. Root development beneath the mulch is similar to other mulched plots.

The Effect of Orchard Mulches on the Plant Nutrients in the Soil. (J. K. Shaw in cooperation with the Chemistry Department.) This is a new project. Previous work has shown that nitrates and replaceable potash abound in orchard soils beneath a hay mulch. We wish to know whether this is also true of other mineral nutrients and whether it is due solely to nutrients in the mulch or to soil conditions brought about by mulching. Two 30-year-old McIntosh trees growing in cultivation were mulched with hay, two with glass wool, which may be expected to produce similar soil conditions, and two are continued in cultivation. Two trenches were dug under each tree and soil samples at several depths were taken. These are now being analyzed to determine total and available nutrients. Similar samples will be taken one or more times each year and analyzed.

Studies of Varieties of Fruits. (J. K. Shaw and Staff.)

Apples. Milton trees bore a good crop this year. As trees get older the irregular shape of the fruit is less pronounced than is that of young trees. Milton is larger, of more attractive color, and later than Early McIntosh; the tree is of far better growing habit and begins to bear earlier.

Sweet Cherries. There are no commercial sweet cherry orchards in Massachusetts; yet it would seem that growers in this State might compete with those who ship in considerable quantities of fruit. Leaf spot and brown rot can be controlled easily. The two most serious difficulties are winter injury to the trees and depredations by birds. Proper choice of site and soil and suitable soil management will go far towards preventing winter injury and it is doubtful whether birds would be very troublesome in orchards of an acre or more. Birds harvested most of the blueberries in two small unprotected plots, but when two acres were planted the mischief of birds became insignificant. It has been suggested that captive hawks or even stuffed hawks might scare away birds. In a limited trial in one of our small blueberry plots a live hawk seemed to keep birds away. It should be remembered that only certain species may legally be kept in captivity.

We have grown in the nursery about twenty-five varieties of sweet cherries and most of them are also in our orchard though not all are in bearing. A few notes on some varieties are here given:

Bing is a dark, red cherry often in our markets. It is meaty, of attractive appearance and good quality, with a small pit. It is not very productive.

Black Republican is another dark cherry of good quality but not very large. It is commonly used only as a pollinator.

Dikeman is small, rather sour and of not very good quality. It is not to be recommended.

Giant is a large, dark cherry, inferior in quality to others of its class.

Napoleon is the yellowish Royal Ann of the Pacific Coast and our markets. It is perhaps the best light colored sweet cherry but not as hardy to cold as other varieties.

Schmidt is one of the best dark cherries, of very good quality and fairly hardy. It is recommended to plant with Windsor as a pollinating variety. Nelson is very similar to if not identical with Schmidt. Paul Rose is a yellow bud sport of Schmidt with a red line down the suture. Neither is superior to Schmidt.

Windsor is the best sweet cherry for Massachusetts. It is dark red, hardy, productive, and of very good quality.

Gold or Starks Gold was very productive and hardy at first. Later the trees were killed apparently by winter cold. It is poor in quality.

Sweet September is a late yellow cherry which is now being advertised by some nurserymen. It appears to be too tender to cold for Massachusetts.

Peaches. Duke of York. An old English peach recently brought to the attention of American peach growers. It is an early white-fleshed peach but is unattractive, poor in flavor, has soft-melting flesh, and is semi-cling. Its value in Massachusetts is very doubtful.

Goldeneast. This is a fine, large, freestone, attractive, yellow-fleshed, midseason peach of very good flavor. It looks very promising.

Redrose is an attractive white-fleshed, late, freestone peach. Flavor was not very good.

New Jersey 102. A medium-season, yellow-fleshed, freestone peach of good quality but not outstanding.

New Jersey 105. A yellow, late, freestone peach; quality only fair.

New Jersey 108. A late, yellow-fleshed, freestone peach; quality poor. Probably ripens too late for Massachusetts.

New Jersey 109. A late, white-fleshed, freestone peach of fair flavor. Not attractive. It may be a little late for Massachusetts in some years.

New Jersey 111. A late, yellow-fleshed, freestone peach, attractive but of only fair flavor. Heavy crop for small tree.

Sungold. A medium-late, yellow-fleshed, freestone peach of very fine flavor and attractive. It has a thick, tough skin and should ship well. The tree is dwarfish and spreading like J. H. Hale.

Grapes. In recent years the New York Experiment Station has bred and the New York Fruit Testing Association introduced many new varieties of grapes. The following varieties are all of this origin:

Erie is a good, early blue grape. The bunch is poor and it is self-sterile. There are better grapes of its season. It seems to be no longer offered by the Fruit Testing Association.

Hanover, Sheridan, Urbana and Wayne all matured fairly well this year but usually our season is too short for them. It is doubtful if any of them should be planted here except under conditions most favorable for maturity.

Several varieties not yet named were fruited. Number 12236 (red) and 12238 (reddish blue) have received the most favorable comment and are regarded as promising. Concord Seedless (blue) and numbers 9975 (blue), 11361 (reddish blue), 11412 and 11679 (both green) appear less promising.

Raspberries. Marcy is still free from mosaic disease, of good quality but rather soft for shipment. It is more desirable than Taylor but it is doubtful if it can replace Latham as a commercial variety.

Marion is a purple raspberry with the undesirable color of that type. It is thought to be superior to Sodus and worth trying if one wants a purple raspberry.

Tahoma appears to be undesirable. The berries are small, soft and sour.

Taylor suffers severely from Mosaic, and its quality is inferior to Marcy.

Among five numbered seedlings from Geneva, No. 13618 seemed most promising. Numbers 5371, 5548, 13108 and 14685 were, for various reasons, considered to be of doubtful value.

Blueberries. Concord. This variety produced very attractive, firm, fine-flavored berries in 1941. There was no tendency to crack after rainy periods. Most berries were large but size was somewhat variable. The scar is large and watery with a tendency for the skin to tear.

Dixi is yet too young to give a good idea of the variety. Bush appears vigorous but yields have been light. Fruit late, large, of good flavor, picks easily, but has a large watery scar.

Jersey. Large, attractive berries make this look like a good variety. The bush is vigorous and yields well. Flavor is excellent if the berries are allowed to ripen well on the bush but very sour if picked a day or two too soon.

June. This variety has improved in growth since the soil was drained, but growth is still weak in comparison with other varieties. Since it is earlier than Cabot, it might have a place for home garden use or roadside stand trade.

Pemberton. This variety continues to look promising because of large size and attractiveness of berries and good yield. Fruit has excellent flavor but the scar is large. There was very little cracking after rainy periods.

Scammell. This variety is probably not adapted to this climate. Leaves are small and growth is not vigorous. Berries are large during first of season but late berries are small. Flavor is good. Berries are firm but they cracked after rainy periods.

Stanley. The performance of this variety was disappointing this year. Growth was poor and yield very light.

Wareham. Berry size was unusually large this year—90 per cup at the start of the season—and held up well. It has a distinctive wild blueberry flavor that some people like. The bush is open and the fruit clusters are small and open, making picking easy. The scar is small. It yields well, but the dark-colored fruit lacks attractiveness. This year it became soft and cracked very badly after rains, and kept poorly in storage.

Fruit Bud Formation in the Strawberry. (R. A. Van Meter.) Differential mulching experiments brought this study to an end with the harvesting of the 1941 crop. Results are now being summarized.

Nature of Winter Hardiness in the Raspberry. (R. A. Van Meter and A. P. French.) One of the serious difficulties of the raspberry grower in Massachusetts is winter injury to the canes and buds. The occurrence is erratic and unpredictable. Little seems to be known about the causal conditions. A study will be made of the rest period, vegetative condition, and chemical composition of the plants in their relations to winter injury. Several seasons' work are likely to be necessary before definite results can be reported.

Storage of Apples in Modified Atmospheres. (L. Southwick and O. C. Roberts in cooperation with Department of Engineering.) Experiments with 40-quart milk cans as gas-tight containers were continued. Attempts were made to maintain definite atmospheres in the cans by daily flushing with nitrogen, by taking out excess carbon dioxide, and by controlling ventilation. The cans were filled on December 2, 1940, with about 35 pounds of rather mature, wrapped McIntosh apples and sealed immediately. These apples at 40° F. generated carbon dioxide at the approximate rate of 2.5 milligrams per hour per kilogram of fruit. Where a sodium hydroxide scrubber was used to wash out the accumulations of carbon dioxide, the oxygen in the cans was reduced to below 3 percent in 8 to 10 days. Complete oxygen depletion was greatly hastened when cans were flushed with nitrogen every day or two.

It was difficult to maintain the desired constant atmospheres in these cans by the methods employed. Since the apples occupied as much as 50 percent of the total space in the cans, respiratory activity itself caused rather abrupt changes in the composition of the atmosphere. Furthermore, a very brief washing period reduced the carbon dioxide content to practically zero. The carbon dioxide increased to an average of 10 percent in the cans between scrubbings. Oxygen percentages varied much less widely around the desired 2 percent level. It was somewhat difficult to keep the oxygen level sufficiently high to prevent anaerobic

respiration unless ventilation was provided. One tight can was left undisturbed with a subsequent CO_2 accumulation of over 60 percent of the total atmosphere.

Through controlled ventilation, one can was operated approximately on the English system of 10 percent oxygen and 11 percent carbon dioxide. With an open 3/8-inch vent near the base of the can, respiration at 40° reduced the oxygen below the 10 percent level. By controlling the amount of leakage through a similar hole at the top of the can, the desired atmosphere was maintained fairly well. Only a very small top opening was needed to allow sufficient air leakage to counterbalance oxygen utilization.

On March 1, one can was opened. The atmosphere in this can had been maintained at less than 1 percent of oxygen with the CO_2 averaging around 12 percent. The apples were in poor condition with scald, skin ruptures, and some internal breakdown. The more highly colored apples were in the best condition both in appearance and eating quality. The flesh was rather soft. A slight alcoholic taste was evidence of anaerobic respiration.

On May 1, another can was opened. The oxygen content of this can had averaged about 2 percent with the CO_2 ranging between 3 and 10 percent. Most of the apples were in good condition with excellent color and no evidence of scald or internal breakdown. There was some soft rot and mold where apples had been injured. Quality was fairly good. A duplicate can was opened two weeks later and here, also, the apples were in good condition though the quality was mediocre. A rather high acidity was a contributing factor.

The can which was operated on the English system was examined on May 13. The oxygen level had varied between 8 and 15 percent. With this system, the sum of the oxygen and CO_2 always equals about 21 percent. There was no scald, core breakdown, or rot, but quality was rather poor.

Where flushing with nitrogen was utilized and a very limited amount of ventilation provided, apples were still in good eating condition on May 13. The oxygen in the can had varied between approximately 2 and 6 percent and the CO_2 between 2 and 12 percent. Just why this treatment gave the best results is not clear unless it was due to the frequent change of atmosphere in the can. The apples (at 40° F.) were better than checks kept at 32°–33° F.

These tests indicate that more uniform control of the atmosphere in a modified-atmosphere storage room is a requisite to the successful operation of such a room. Undoubtedly, the wide fluctuation in the composition of the atmospheres in the cans was a determining factor in lowering eating quality.

The storage room which was "gas-proofed" in 1940 was not sufficiently tight to allow respiration to reduce the oxygen to the desired 2 percent level. A contributing cause of this failure was the fact that brine coils and the shape of the room allowed for only partial filling. This room was opened for inspection at 10 a. m. on February 24 and closed again at 5 p. m., resulting in a total loss of the artificial atmosphere. The oxygen was again lowered to around 10 percent which proved to be the minimum obtainable. The room was opened on March 24 and the fruit placed in another room at 32° F. The Wealthy and Gravenstein apples were past good eating condition; Cortland were fair to good; Delicious were very firm and in excellent condition. Golden Delicious were also in excellent condition and, where individually wrapped, these fruits showed no shriveling. McIntosh comprised the bulk of the apples. These were fairly ripe but not too much so for immediate use. Quality was good and somewhat better than that of similar apples stored as checks at 32° F. (Checks stored at 40° F. in normal air showed internal breakdown.) There were considerable differences between different lots of fruit. In general, the late picked McIntosh had the best quality. High color was associated with high quality. Some rot was in evidence on individual fruits. Many apples did not hold up well at room temperatures, largely because

of overmaturity. Those kept at around 34° F. retained fair eating quality for at least a month. A few fruits subsequently split open.

During the summer certain leaks in this room were corrected, the coils were removed, and a small automatic blower system was installed. This arrangement allowed for the storage of 100 additional boxes. With the 300 bushels, mostly McIntosh, this room is now considered sufficiently full and gas-tight for effective operation as a modified-atmosphere storage room. It was filled and temporarily sealed up in October but later the apples were removed in order that some alterations might be made. It was again filled and sealed on November 27. Previous leakage tests indicated less than 5 percent leakage per 24 hours. At the time of this writing (December 20), this storage is performing satisfactorily. The oxygen level is now down to 2 percent.

It is entirely possible that modified-atmosphere storage, especially for McIntosh, may shortly displace in some degree conventional cold storage methods. It seems to offer advantages that are very desirable and perhaps necessary for the continued prosperity of the industry.

Study of "Bud Sports" of the McIntosh Apple. (J. K. Shaw and L. Southwick.) Trees of 21 so-called "bud sports" were planted in the spring of 1941. Three of these have been propagated for several years, while the others are selections from orchard trees. Half of these are on dwarfing and half on vigorous stocks. The purpose of this planting is to maintain the selections and to see what color type of apples they bear. Most of them are supposed or known to be non-striped strains.

Trees of six forms are ready for orchard planting next spring for the purpose of measuring accurately not only the color type of the fruit but also the vigor, productiveness, and other characteristics of both tree and fruit.

Nutrition of the High bush Blueberry, Especially in Relation to Soil Reaction. (J. S. Bailey.) Mixing lime with the soil reduced the growth of blueberry plants. Mixing 5 percent peat with the soil reduced slightly the bad effects of the lime. This work was reported in the *Proceedings of the American Society of Horticultural Science* 38, 1941.

An experiment was started in the spring of 1941 to compare the value of cow, horse, and hen manure as fertilizer for blueberries. Manures have been thought to be harmful to blueberries, especially when applied on soils with a pH above 5. To date the plants look fully as good as those fertilized with mineral fertilizer.

Blueberry Culture. (J. S. Bailey.) During the summer a diversion ditch was constructed around the experiment station blueberry planting so that trouble from erosion should be reduced to a minimum.

The plantings yielded a little over 3000 quarts as compared with 2000 quarts in 1940.

Experiments to control the cranberry fruit worm on blueberries by dusting were continued. Because so few worms were present, even in the checks, the results were not conclusive.

The budding work of 1940 was a complete failure. The bud shields stuck to the stocks but the buds died. This work was repeated in 1941. The buds were set low and protected for the winter by piles of sawdust.

Since the war has cut off the supply of imported peat which has been quite generally used for propagating blueberries, a substitute must be found. A comparative test of several domestic peats was started in the spring of 1940. Nothing which is superior to the imported peat has been found. A leaf mold from Massachusetts and a sphagnum peat from Maine compare favorably with the imported peat.

A light supplementary application of ammonium sulfate about June 7 was given all the blueberries except those in the manure test. The improved appearance of the plants and the increased yield over previous years indicate that this was a good practice.

Bulletin 358, Blueberry Culture in Massachusetts, was revised.

Premature Dropping of McIntosh Apples. (L. Southwick.) Work on this project largely concerned investigations with "hormone sprays." Some chemicals such as naphthalene acetic acid and certain of its salts, naphthalene acetamide and some others, have been shown to delay natural drop of apples at harvest when applied in dilute spray solutions. These chemicals and several commercial proprietary compounds employing these active ingredients were used in field tests in 1940 and 1941. Bulletin 381, published in February, 1941, summarized the results of experimental work conducted in 1940 and in it the authors attempted to evaluate the method of "hormone spraying" especially in relation to McIntosh. Further tests in 1941 revealed no very different results. There was some evidence that under certain conditions, drop-control sprays on McIntosh were not so effective as in 1940. Many check trees dropped comparatively little this year. In most cases, however, the preharvest drop from sprayed trees was less than that from check trees in the same block. Some typical percentage drop comparisons, sprayed and unsprayed, follow: 3.7 and 14.5 percent; 12.9 and 20.2 percent; 2.3 and 7.5 percent; 10.2 and 13.4 percent; 11.6 and 21.4 percent; 7.3 and 18.5 percent; 13.9 and 13.4 percent. It is apparent from these figures that degree of control was not consistent.

There is some indication that the temperature at the time of application may be important. Possibly fruit growers should wait for temperatures above 60° F. before applying a drop-control spray. A more definite statement on this point must await further experiments.

A limited test with Milton indicated little benefit from spraying. The sprayed trees dropped 31 percent of the total crop compared with 34.6 percent from the check trees.

Results again demonstrated the desirability of using standard strength sprays with McIntosh. Weaker sprays were usually less effective. Doubling the standard strength increased the effectiveness of applications. How much improvement in drop control would be required to offset the increased cost of stronger sprays is problematical and depends on several factors. It can be stated with some assurance, however, that the so-called standard strength of "hormone sprays" should not be reduced with McIntosh in this State.

The use of special stickers or summer oil seems to merit some consideration. Theoretically, these materials should tend to improve coverage. Actually, the benefits from their inclusion in hormone sprays have been variable. Usually, drop control has been somewhat better although in some cases improvement has been negligible. It is at least certain that spreaders and stickers are not effective substitutes for good coverage.

Dusts were tried this year for the first time. These were made up by two commercial concerns and were compared with spray applications. In about half the tests, dust was only slightly inferior to spray in lessening pre-harvest drop. In the others, dusting was not effective. It is true also that spraying was practically ineffective in some cases. The heavier applications of dusts (4 pounds per tree) seemed more effective than lighter dosages. Until further evidence is at hand, the use of hormone dusts by growers is recommended for trial only.

Miscellaneous Work

Soil Acidity in the Orchard. Lime was applied to a Sudbury orchard in which aluminum toxicity was suspected, as mentioned in the report of last year. It appears that both grass and trees were improved by the treatment. With the increasing use of wettable sulfur the danger of injuriously high acidity becomes greater. Not only is there danger of aluminum toxicity, but nitrification in the soil decreases as the soil acidity increases.

Lime and Phosphorus in Planting Trees. We have as yet no evidence that phosphorus is directly beneficial to apple trees on our soils; we know that it is readily fixed in the soil and it follows that orchard applications may not pass into the relatively deep-rooted apple trees. An orchard of 36 McIntosh trees of a single strain on three clonal stocks was planted in the spring of 1941. One third of the trees were treated with 10 pounds dolomitic limestone, one third with 5 pounds triple superphosphate, and one third were untreated. The materials were placed in the bottom of the planting holes and well mixed with the soil. As measured by trunk diameter increase, the trees treated with lime grew most, those treated with phosphorus least, while the untreated trees were intermediate.

Weed Killing. The attempt to get rid of wild cherries, particularly choke cherries, around the peach orchards was continued. A new weed killer, ammonium sulfamate, was tried. It looks very promising. Used at the rate of ¾ pound per gallon water, one application was enough to kill small choke cherries and kill or badly damage black cherries. Chlorate weed killers used at the same strength were not so effective on choke cherries and were ineffective on black cherries.

Ethylene Dichloride Emulsion for Control of Peach Tree Borers. Because of reports of damage from the use of this material in other sections, it is being thoroughly tested in the station orchards. It has been used in 1939, 1940, and 1941 in one orchard and in 1940 and 1941 in several others. Applications have been made at 15-day intervals during the fall. The emulsion has been used (1) according to directions, (2) at slightly higher concentrations, and (3) in slightly larger quantities, than recommended. Only one case of injury has occurred; some very vigorous late-growing suckers from the base of some trees were injured when applications of the emulsion at the concentration for three-year old trees was applied. This was an overdose for the year-old suckers. Unseasonably hot weather following the application may have had an effect. Injury has never occurred when applications were made according to standard directions.

Sawdust Mulch. In the summer of 1938, a sawdust mulching program was begun in a small block of bearing apple trees An average of about 4 inches of sawdust was placed under alternate trees to determine the effect of sawdust on subjugation of sod, on soil nutrients and acidity, and finally on tree growth and production. The sawdust had little effect in subduing the grass, which proceeded to grow apace throughout the summer and fall. Unlike hay or straw, which tends to mat down, sawdust does not tend to smother grass. No additional applications were made during the next three years. Neither deleterious nor particularly favorable effects on soil or tree have been observed to date.

In November and early December of this year, a considerably greater amount of sawdust was applied to the same trees. This time, however, the sod on half of the area under the branch spread was taken up and the soil shaken out. The other half was left in sod. Sawdust to an average depth of 6 inches was applied over the whole area. It is intended to determine the comparative feasibility of using a sawdust mulch on cultivated soil and on sod in a bearing orchard.

DEPARTMENT OF POULTRY HUSBANDRY

R. T. Parkhurst in Charge

Broodiness in Poultry. (F. A. Hays.) A number of specific facts have been established in this study of the inheritance of the broody instinct in Rhode Island Reds. Some of the most significant findings are the following. The length of the non-productive period associated with broody behavior remains rather constant at about fifteen days. Degree of broodiness as measured by the number of broody periods is governed by inheritance. The time of appearance of the broody instinct in the life of a female is highly variable. In flocks bred to eliminate the broody instinct, the onset of broody behavior in individual females has been about 57 percent in the first laying year, 34 percent not until the second laying year, and about 8 percent not until the third laying year. These three classes of females when used as breeders gave about the same percentages of broody daughters. The selection of female breeders that did not exhibit the broody trait during their first two laying years was effective in reducing the incidence of broodiness in the flock. There is no evidence of sex-linked inheritance.

At present efforts are directed toward the establishment of an entirely non-broody line by applying all of the information now in hand.

Statistical Study of Heredity in Rhode Island Reds. (F. A. Hays and Ruby Sanborn.) This project is devoted entirely to the preparation and analysis of experimental data used for publication. During the year the following papers have been prepared: The Importance of Length of Incubation Period in Rhode Island Reds, Bulletin 384; Breeding for High Viability, a study covering seven years, has not yet been published; A Preliminary Study of Molting Behavior, covering three years, has not yet been published; and A Study of Variation in Egg Weight, covering five years, is now in preparation.

A Genetic Study of Rhode Island Red Color. (F. A. Hays.) This study has to do with the genetic complex concerned in the inheritance of Rhode Island Red plumage and possible relationships between characters affecting fecundity and plumage color. Two lines of birds are being carried, one breeding true for late sexual maturity and the other selectively bred for early sexual maturity. There is some evidence that one or both of the dominant genes for early sexual maturity affects plumage color. The relation between the red of the Rhode Island Red plumage and the buff of the Orpington is also being studied.

Rate of Feathering in Rhode Island Reds. (F. A. Hays.) This experiment is concerned primarily with the genetic aspects of rapid and slow chick feathering. To study this problem three lines have been developed with respect to rate of chick feathering; namely, a rapid-feathering line produced exclusively by the use of breeding males that showed complete back feathering at eight weeks of age; a slow-feathering line bred entirely from sires showing the absence of back feathering at eight weeks of age; and a check line bred primarily for high fecundity, with some of the sires rapid feathering and some slow feathering.

In the spring of 1941 the seventh generation was produced in the three lines, and gave the following percentages of rapid-feathering sons at eight weeks: line 1, 100; line 2, 10; and the check line, 84. The chicks were also classified for the sex-linked gene for rapid feathering at twelve days of age. The males in the three lines gave the following percentages with the sex-linked rapid-feathering gene: line 1, 49; line 2, 0; and the check line, 6. An attempt was also made to separate the rapid- and slow-feathered females by grading the feather growth in the back region at four weeks of age.

All data available indicate that in Rhode Island Reds the sex-linked gene for

rapid feathering may or may not be present in rapid-feathered stock. There is, however, a definite sex difference in the rate of feathering in the dorsal region.

The Effectiveness of Selective Breeding in Reducing Mortality in Rhode Island Reds. (F. A. Hays.) This is a cooperative project with the Regional Poultry Research Laboratory, East Lansing, Michigan. In the spring of 1934 a project was begun to test in a small way the effectiveness of selective breeding in reducing mortality in Rhode Island Reds.

The foundation stock consisted of pedigreed birds that had been bred for characters associated with high fecundity since 1916. During the first five years females alone were kept to the age of 18 months. Beginning with the sixth generation, hatched in 1939, both males and females were retained to the age of 18 months. An attempt has been made to establish two lines, one for low mortality and the other for high mortality. Breeding males and females 24 months of age were used as breeders and the sole basis of their selection was the mortality rate of their sisters during their first laying year. A check line consisted of birds bred for high fecundity. Inbreeding in both lines was avoided by the constant use of males drawn from the check group but selected on the mortality basis. Limited facilities available permitted the production of about 100 birds in each of the mortality lines, and since 1939 about equal numbers of males and females have been carried to 18 months of age. Complete mortality records have been kept and post-mortem examinations have been performed by the Department of Veterinary Science.

The limited data now available indicate in general that selective breeding was effective in small groups in reducing the mortality rate from the miscellaneous diseases and disorders appearing under our conditions.

Genetic Laws Governing the Inheritance of High Fecundity in Domestic Fowl. (F. A. Hays and Ruby Sanborn.) Many phases of this problem have been studied and reported upon. At the present time special attention is being given to the genetics of intensity and winter pause. These two characters have a rather complex inheritance and their interactions with other characters are very significant. Possible interactions between genes affecting intensity and genes affecting egg size are being given close study. The mortality problem as affected by selective breeding is also being given constant attention.

Recent findings indicate that chicks emerging early from the shell are likely to be superior from the standpoint of fecundity; that heavy body weight in both males and females at six months of age is a significant criterion of future low mortality; and that selective breeding for characters affecting egg production has not reduced the viability of the stock. Reducing the variability in egg production is a slow process because of the complex nature of inherited factors and environmental interactions.

A Study of Fertility Cycles in Males. (F. A. Hays.) Histological studies of testes from males in a wide age range, taken throughout a two-year period, indicate that both age and season affect the rate of spermatogenesis. There is definitely a cyclical behavior in males with respect to their fertility. Preliminary breeding tests have not indicated that fertility is governed by inherited factors. This problem of possible inherited factors is being studied further along with environmental factors that may be in operation.

Physiological Relationships Between Molting Behavior and Fecundity Characters. (F. A. Hays.) Bi-weekly individual molt records are being continued on a fourth series of males and females from parents with known molt records. The first breeding stage of this project began in the spring of 1941. Two lines

were started, the first from females laying but few eggs during molt and the second from females laying for a relatively long period during the molt. Preliminary studies over three years indicate that the ability to lay eggs and molt simultaneously is a highly desirable trait. The change in body weight of males and females during the annual molt is not very significant. Males already used required an average of about 94 days to shed their wing primaries while females averaged about 119 days. Some females lay very few eggs during this period while others lay up to 40 or 50 eggs. Good females should shed at least three primary wing feathers before laying stops. Completion of wing molt in December appears to be desirable from the standpoint of first-year egg production.

Miscellaneous Genetic Studies. (F. A. Hays.) Linkage studies include genes for shank feathering, comb form, and mottled ear lobes in Rhode Island Reds. An effort is also being made to isolate the sex-linked gene for early sexual maturity. A new method for separating sexes in Rhode Island Red chicks is being studied and offers some possibilities. For auto-sexing, a gold-barred bird is being developed on a limited scale.

The Use of Crab Meal in Poultry Rations. (Raymond T. Parkhurst and Marie S. Gutowska with C. R. Fellers of the Department of Horticultural Manufactures cooperating.) In broiler production studies, Red–Rock cross chicks were used and comparisons involved the 1940–41 New England College Conference starter as the basal ration, the basal ration with 5.5. percent crab meal replacing 2.5 percent fish meal, the basal ration with 5.5 percent crab meal replacing 5 percent milk and 2.5 percent fish meal, and the basal ration with 3 percent fish meal replacing 5 percent of dried skimmilk. The mineral contents of the rations were adjusted. There were no significant differences in growth, mortality, feed efficiency, feathering, or pigmentation.

When crab meal replaced fish meal on an equal-protein basis (4 pounds for 2.5 pounds) in the Massachusetts complete all-mash laying ration, there were no significant differences in egg production, weight of eggs, feed efficiency, yolk color, albumen quality, fertility, and hatchability. The egg production averaged higher in the fish meal group, based on the birds that lived, but fewer birds died in the crab meal group; with the result that total production, total income, and the feed cost per dozen eggs were practically the same for the birds on the two rations. The results to date show that crab meal is a satisfactory ingredient in poultry rations and can replace fish meal on an equal-protein basis. Further comparisons of these feeds are in progress.

The Manganese Requirements of Laying Hens. (M. S. Gutowska and R. T. Parkhurst.) The effect of the addition of manganese to complete all-mash laying rations was investigated from a practical standpoint. Forty-eight Rhode Island Red pullets were kept on a basal all-mash ration for 12 lunar months (2 periods each lasting 6 lunar months). The two high-manganese groups received in their diets 76 and 61 parts per million of manganese; the two low-manganese groups, 17 and 24 p. p. m., respectively. The data showed no appreciable differences in egg production, feed efficiency, fertility, hatchability, and livability between the compared groups; but the shell-breaking strength of eggs laid by the pullets on high-manganese rations was significantly greater than that of eggs laid by birds on the low-manganese rations, although the shell texture was not unsatisfactory in the latter groups. It was concluded, because all-mash laying rations containing as little as 17 and 24 p. p. m. of manganese did not produce manganese deficiency symptoms in laying hens in a period of 12 lunar months, that even these levels in laying rations can be considered satisfactory from a practical viewpoint.

The Effect of an Excess of Calcium in the Diet. (M. S. Gutowska and R. T. Parkhurst.) The results of this experiment showed that an excess of calcium in the ration of laying hens lowered the production value of the diet, and that 3 95 percent of calcium in the diet of laying hens having a normal dietary level of phosphorus and ample vitamin D intake was excessive. However, there was no significant difference in the egg shell breaking strength, the average egg weight, and the fertility and hatchability of eggs between the groups of birds receiving the varying levels of calcium.

The importance of a control of the mineral balance of laying rations by means of chemical analysis at regular intervals is suggested.

The Value of Pulverized Calcite Flour as a Source of Calcium for Laying Hens. (M. S. Gutowska and R. T. Parkhurst.) The object of this experiment was to compare qualitatively two rations with different sources of calcium: pulverized plain calcite and oyster shell meal, at the same quantitative level. The manganese content of the rations was estimated to be close to the assumed optimum for laying pullets.

The data obtained from two flocks of 24 Rhode Island Red pullets during 12 months showed no significant differences in production, body and egg weight, feed efficiency, egg shell breaking strength, hatchability, and fertility. The egg quality was equal in the two flocks.

It was concluded that pulverized plain calcite is as good a source of calcium as oyster shell meal for laying pullets; but its biological value as a mineral supplement for laying hens is not higher than that of oyster shell meal.

The Phosphatase Activity as a Factor of Calcium Deposition and Egg-Shell Formation. (M. S. Gutowska and R. T. Parkhurst, with the cooperation of E. M. Parrott and R. M. Verberg of the Chemistry Department.) Phosphatase activity as a factor of shell formation is studied by the determination of plasma and oviduct phosphatase activity. Four groups of hens, good and poor producers, with good and poor egg shell, are being compared in this regard. The phosphatase activity is determined according to a modification of King-Armstrong method.

Electric Brooding. (W. C. Sanctuary in cooperation with Professor C. I. Gunness of the Engineering Department.) The use of soil cable under 4 inches of sawdust litter materially reduced moisture content of litter, when used continuously, but at an excessive cost. The use of insulation plus restricted ventilation also reduced the moisture content of the litter materially, but not so much as the continuous use of the soil cable. The use of damp (40 percent moisture) sawdust from the start of brooding produced no deleterious results except for a large number of crooked toes thought to be due to cold floors. Because of high moisture content, the litter froze into a solid block on cold nights.

Combining Meat and Egg Production. (W. C. Sanctuary and J. H. Vondell.) The standardization of body weight in Barred Plymouth Rocks at 6 pounds by December 1 has been well established. The 1938 generation had a mean weight just below 6 pounds. The generations of 1939 and 1940 had a mean weight just a trifle above 6 pounds. There has been some improvement in meat quality as measured by fleshing upon the breasts at 8 weeks of age and later as adults. One adult male of the 1941 generation has approached the extreme "broad-breasted" type now produced in one variety of turkey. Egg production has improved also, three 300-eggers having been produced in the last two years largely because of improvement in intensity (rate) of production.

Sexing by Down and Shank Color. (W. C. Sanctuary.) The sexing by down and shank color of 948 College pedigreed Barred Rock chicks was done with a 95.36 percent accuracy compared to a 95.15 percent accuracy by the vent process method with the same chicks. The chicks were first judged by the down and shank characteristics.

Restricted Feeding on Range. (J. H. Vondell.) At 10 weeks of age, one half of the College Barred Rock chicks was placed on a restricted plan of feeding, while the remainder continued on the free-choice feeding of mash, oats, and corn.

The restricted plan consisted of feeding mash and oats until 10 a. m., when the hoppers were closed and no feed given until the 4. p. m. allotment of whole corn. The pullets were housed September 12 and both lots were placed on full feeding. The restricted plan resulted in a saving of 1.52 pounds of feed per chicken during the 15-week period. At 6 months of age the restricted and full-feeding lots weighed exactly the same, 5.85 pounds. There was no difference in maturity as determined by age at first egg. The laying-house mortality to April 1 was practically the same for the two lots. Also, egg production was quite close: 57.86 percent for the full-feeding and 62.88 percent for the restricted lot.

These studies are being continued.

DEPARTMENT OF VETERINARY SCIENCE

J. B. Lentz in Charge

Poultry Disease Control Service. (H. Van Roekel, K. L. Bullis, O. S. Flint, and M. K. Clarke.)

1. *Pullorum-Disease Eradication.* During the 1940–41 season the laboratory tested 309 chicken flocks representing 527,328 birds and 538,589 tests. The percentage of reactors (0.09) was the lowest in the twenty-one-year testing period. Of the total 478 reactors, the bulk was identified in one flock.

Testing service was rendered to flock owners in 11 counties. Middlesex and Worcester counties led in the number of birds tested. No reactors were found in Barnstable, Essex, Hampshire, Plymouth, and Worcester counties.

Five flocks which were non-reacting the previous year revealed infection during the 1940–41 season. In two instances a plausible explanation for the infection was obtained. In all instances but one the percentage of reactors was very low, less than one-half of 1 percent.

Flocks tested for the first time revealed the highest percentage of infection. Among the flocks (41) tested for two consecutive years, no reactors were found. Among the 210 flocks tested for three or more consecutive years, representing 437,145 birds and 446,694 tests, 0.08 percent reactors was revealed.

Approximately 88 percent of the total birds tested was confined to 100 percent tested, non-reacting flocks (256). Forty-three flocks were partially tested and non-reacting, representing 28,874 birds. Ten flocks were classified as positive, representing 34,853 birds.

Of the total birds tested, 490,759 were females and 47,830 were males. The percentages of reactors were 0.08 and 0.17, respectively.

A total of 4,417 samples collected from fowl other than chickens was tested for pullorum disease. The species tested included turkeys (4,259 tests), pheasants (115), guinea fowl (22), geese (13), ducks (5), and quail (3). Reactors were detected in three of the 32 turkey flocks, but in only one instance was *S. pullorum* isolated. No reactors were detected among the other fowl tested.

The testing results indicate that Massachusetts is making progress in eliminating pullorum disease from its chicken and turkey breeding flocks.

2. *Diagnostic Service.* During the year, 2,264 specimens were examined in 533 consignments. Personal delivery of specimens was made in 335 cases. The specimens may be classified as follows: 1,878 chickens, 256 turkeys, 38 canine feces, 24 pheasants, 11 each of foxes and goat feces, 7 pigeons, 6 trout, 4 bovine semen, 3 each of crows, peafowl, and ruffed grouse, 2 each of bovine organs, bovine skin scrapings, calves, canine, equine nasal swabs, mink, rabbits, and sheep, 1 each of bovine rumen contents, canary, equine, and pork.

The incidence of the more common and important disease conditions observed in chickens during the past five years is as follows:

	1936-37	1937-38	1938-39	1939-40	1940-41	Total
Avian tuberculosis	1	1	3	1	1	7
Coccidiosis	35	64	97	82	63	341
Enterohepatitis	2	7	6	7	7	29
Epidemic tremor	8	35	22	19	12	96
Fowl cholera	11	3	16	12	13	55
Fowl coryza	5	2	1		3	11
Fowl paralysis	37	45	77	47	51	257
Fowl pox	8	30	21	7	9	75
Fowl typhoid	4	2	11	4	1	22
Infectious bronchitis	40	31	48	57	31	207
Infectious laryngotracheitis	12	9	19	14	13	67
Internal parasites	23	21	41	26	34	145
Kidney disorders	17	15	37	21	19	109
Leukemia	7	3	6	3	5	24
Nutritional encephalomalacia	1	7	13	8	6	35
Paratyphoid	1	2	3	1		7
Perosis	4	2	4	3	3	16
Pullorum disease	39	46	49	32	28	194
Reproductive disorders	22	14	20	21	17	94
Rickets	8	6	19	19	10	62
Tumors	53	46	79	53	66	297
Ulcerated gizzards	1	15	14	15	10	55
Unknown disease	9	11	24	26	33	103
Unknown pullet disease	6	6	11	9	14	46

The 256 turkeys were received in 44 consignments. Paratyphoid, coccidiosis, enterohepatitis, and ulcerative enteritis were the conditions most frequently encountered. Pullorum disease was observed only once for the second consecutive year and these poults came from a source outside of the State. Pullorum disease was, however, established in a Massachusetts flock through necropsy of a reacting turkey. Swine erysipelas and fowl cholera were each identified once. This is the first time that fowl cholera has been recorded in a Massachusetts flock. *Capillaria contorta* was identified twice in one flock. This parasite produced symptoms in quite a number of birds in both instances.

Capillaria plica was observed in one fox. We are indebted to the Zoological Division, Bureau of Animal Industry, United States Department of Agriculture for identification of the parasites in the fox and in the turkeys.

Listerellosis was identified in a canary. All females (eight) in the aviary died within a two-week period. The males in a separate cage were not affected.

3. *Flock Mortality Studies.* These studies have been continued to obtain additional data on causes of adult mortality and to furnish information for genetics experiments. Necropsy examinations were made on 208 morbid and dead birds from the flock which was hatched in the spring of 1940 at the Experimental

Poultry Farm. There were 147 females and 61 males. A wide variety of diagnoses was made on these birds, but no unusual outbreaks of disease were noted. The mortality in this year's flock was widely distributed over the year, whereas the mortality in flocks hatched in previous years had a tendency to be concentrated in the late spring or just after the birds were more than one year of age. Cannibalism was materially reduced in this group of birds, whereas fowl paralysis and staphylococcosis were markedly increased.

4. *Salmonella Types Isolated.* The identification of paratyphoid organisms isolated from diseased specimens continued during the past year, and 21 were added to those previously reported. Eighteen were *S. typhi-murium*, one was *S. anatum*, and two (from different organs of the same specimen) appear to be a new type. These 21 strains came from six flocks. One strain was isolated from a pigeon and all others from turkeys (7 mature and 13 poults).

During the past year, 4104 turkey blood samples were tested for paratyphoid infection by the macroscopic tube agglutination test. An autogenous antigen of *S. typhi-murium* was used as a test fluid. While infected birds can be detected by such a procedure, the method can not be relied upon to eliminate the infection to the degree accomplished in pullorum-disease testing. Owners of flocks that are apparently free of this infection should investigate thoroughly the history of the source from which stock may be introduced.

We are greatly indebted to Dr. Philip Edwards, Department of Animal Pathology, University of Kentucky, Lexington, Kentucky, who identified these strains as to type.

5. *Avian Encephalomyelitis.* The infective agent was passed through chicks (intracerebral inoculation) 21 times during the past year and is now in its 125th passage since its first isolation. Its characteristics do not appear to have undergone any permanent change during the twelve months. An attempt was made to determine the presence of avian encephalomyelitis virus in the brain of adult birds which had exhibited typical symptoms of the infection as chicks. Six hens of this type were destroyed and brain suspension prepared from each for inoculation intracerebrally into baby chicks. In no instance did the brain suspension produce symptoms of avian encephalomyelitis. A suspension prepared from the ovary of one of the six birds also gave negative results when inoculated into baby chicks. The virus appears to lose its potency very slowly if stored at 10° C. ±. This conclusion is based on inoculation of three brain suspensions prepared 10/8/38, 4-12/39, and 8/24/39 and stored until 1/21/41. The oldest (stored 837 days) produced typical symptoms in 50 percent of the chicks inoculated; the next oldest (stored 650 days), in 67 percent of the chicks; and the most recent (stored 517 days), in 86 percent of the chicks.

Additional data were obtained from inoculation of embryonated eggs and transmission of infection to chicks hatched in the incubator at the same time with the inoculated embryos. A total of 188 ten-day embryos was inoculated in six different settings of eggs. Of the 91 chicks hatched from these embryos, 23 showed typical symptoms of avian encephalomyelitis. Seven of these chicks showed symptoms before they were taken from the hatching tray, and one chick showed no symptoms until it was 29 days of age. All others showed symptoms at ages between these extremes. None of the 107 chicks exposed in the incubator while hatching developed symptoms of avian encephalomyelitis infection. The effect of fumigation on brain suspensions of avian encephalomyelitis virus was investigated in three trials. Chicks inoculated with a virus suspension previously fumigated by the standard formaldehyde gas method did not develop clinical symptoms.

Consignments of chick brains were received from Georgia, New Mexico,

Ohio, and Wisconsin. Avian encephalomyelitis was definitely identified in three of the four consignments.

6. *Infectious Bronchitis Studies.* During the past year investigations were undertaken in the control of infectious bronchitis, which is a widespread, highly infectious, communicable respiratory disease of chickens causing serious losses among young chicks and laying birds.

Field investigations were started with the objective of inoculating flocks during the growing age in the hope of producing an immunity which would be of sufficient duration so that the birds would pass through at least one laying season without contracting the infection. Fourteen flocks, representing approximately 40,000 birds, were inoculated during the months of June, July, and August. The inocula were prepared from laboratory birds inoculated with a known infectious bronchitis virus. Preliminary observations reveal that birds ranging in age from four weeks to four months can be inoculated without serious objectionable post-inoculation results. However, the inoculation of birds six to ten weeks of age produced the most satisfactory results. Chicks under four weeks of age and laying birds should not be exposed to the infection.

To date no definite evidence of the disease has appeared among the birds in the inoculated flocks. Later in the season a critical test will be applied to the various flocks to determine their resistance to infectious bronchitis virus.

Laboratory investigations are in progress to develop a practical and economical method for the production and administration of the virus for flock inoculation. The development of a practical and successful inoculation program to control infectious bronchitis will mean a great economic saving to the Massachusetts poultry industry.

7. *Farm Department Brucellosis Control and Eradication.* The laboratory cooperated in this work by testing 639 bovine and 53 swine blood samples, by the standard tube agglutination method.

Studies of Neoplastic and Neoplastic-like Diseases. (Carl Olson, Jr.) The lymphoid tumor experimentally transmissible in chickens has been maintained in serial passage during the past year. It has retained its fundamental characteristics and in its later passages has shown no tendency to change its behavior. Apparently the tumor has assumed a fixed pattern for its action in experimental birds. The results of the first thirty serial passages have been published in an article "A transmissible lymphoid tumor of the chicken" appearing in *Cancer Research* 1: 384-392, 1941.

The collection of 384 spontaneous tumors of chickens has been investigated and much interesting information has been the result of this study. The collection was derived from three sources; namely, cases of tumor submitted to the Diagnostic Laboratory during a two-year period, cases of tumor occurring in a flock from which nearly all birds found ill or dead were examined, and cases of tumor found in birds from other miscellaneous sources. Twenty-three different types of neoplasia were found in the collection. The most common was lymphocytoma, as slightly over half (55.5 percent) of the cases were of this variety. Six other types (leiomyoma, embryonal nephroma, myelocytoma, leukosis, epithelioblastoma, and fibrosarcoma) collectively comprised about one-third (32.8 percent) of the collection. Other varieties of neoplasia found were carcinosarcoma, neurogenic sarcoma, hemangioma, fibroma, cholangioma, hepatoma, histiocytic sarcoma, myxoma, thymoma, rhabdomyoma, osteochondrosarcoma, fibrochondrosarcoma, melanoma, lymphangioma, mesothelioma, and teratoma.

Three forms of lymphocytoma were found: diffuse, nodular, and combined diffuse and nodular. A possible explanation for the existence of three forms was

developed from study of the material, and is based on the inherent resistance of the individual bird to growth of the tumor. Thus in diffuse lymphocytoma the host has but little resistance to growth of the tumor, allowing it to assume a diffuse character. In nodular lymphocytoma the host has considerable resistance to growth of the tumor, causing it to be restricted and nodular in form. The combined diffuse and nodular form develops when there is but moderate resistance of the organ or tissue in which the tumor is growing.

WALTHAM FIELD STATION

Waltham, Massachusetts

Ray M. Koon in Charge

The members of the research staff of the Waltham Field Station are assigned to the unit by the Departments of Botany, Entomology, Floriculture, Horticulture, and Vegetable Gardening. Reports of these departments give results of investigations conducted at this station.

Soil Testing Service. Testing soil for commercial vegetable growers, mushroom growers, florists, nurserymen, greenkeepers, arborists, vendors of loam, and home gardeners has long been regarded as an important service which the Field Station has rendered. More recently this program has been extended to include service to the State Department of Public Works, the Metropolitan District Commission, Works Project Administration, and town and city administrations. There is no doubt that this effort is effective, particularly when the soil test is followed by a personal interview between the client and the technician. The total number of soil samples tested in 1941 was 6676.

Field Day. The twenty-third annual Field Day on August 6, 1941, attracted the usual number of visitors, about 1200. Perfect weather made it one of the most comfortable Field Days ever held. In an endeavor to increase the interest in the vegetable contests a few more varieties were added to the list. Valuable prizes were offered by the Boston Market Gardeners Association for the three best market packages of Bunched Carrots, Summer Pascal Celery, White Celery, Trellis Tomato, Straightneck Squash, Sweet Corn, and Cucumber. An auction of the vegetables entered in the contests proved an interesting innovation.

PUBLICATIONS

Bulletins

378 Annual Report for the Fiscal Year Ending November 30, 1940. 112 pp. February 1941.

The main purpose of this report is to provide an opportunity for presenting in published form, recent results from experimentation in fields or on projects where progress has not been such as to justify the general and definite conclusions necessary to meet the requirements of bulletin or journal.

379 Trace Metals and Total Nutrients in Human and Cattle Foods. By E. B. Holland and W. S. Ritchie. 31 pp. July 1941.

This information concerning the composition of various plant materials is provided because of the very general interest in the nutritional function of certain trace elements.

380 Pasture Culture in Massachusetts. By William G. Colby. 44 pp. October 1941.

Pastures are of great economic importance in Massachusetts agriculture, and this study represents an attempt to organize such available information as may have a bearing on their best management.

381 Spraying to Control Preharvest Drop of Apples. By Lawrence Southwick and J. K. Shaw. 16 pp. February 1941.

The use of "hormone sprays" to reduce preharvest drop is a new development. This bulletin reports results of recently conducted tests in an attempt to evaluate the method, especially in relation to McIntosh

382 The Propagation of Some Trees and Shrubs by Cuttings. By William L. Doran. 56 pp. March 1941.

The detailed information regarding recent developments in plant propagation dealt with in this bulletin should be of significant economic importance, especially to nurserymen and foresters.

383 The Sanitary Evaluation of Private Water Supplies. By Ralph L. Francis. 11 pp. March 1941.

A safe water supply for rural homes is of prime importance. This is an explanation of some of the problems involved, with special attention to contamination and its detection.

384 The Importance of Length of Incubation Period in Rhode Island Reds. By F. A. Hays. 12 pp. July 1941.

This represents an attempt to determine whether length of incubation period may serve as a criterion of the future performance of chicks.

385 Natural Land Types of Massachusetts and Their Use. By A. B. Beaumont. 16 pp. May 1941.

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